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THE PERPLEXED FARMER

HOW IS HE TO MEET ALIEN COMPETITION?

Three Lectures

GIVEN AT BRUSSELS

BEFORE THE BELGIAN ROYAL CENTRAL SOCIETY OF AGRICULTURE

BY

GEORGES VILLE

TRANSLATED FROM THE FOURTH FRENCH EDITION

with additional matter supplied by the Author

BY WILLIAM CROOKES, F.R.S. V.P.C.S. &c.

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PREFACE

TO

THE ENGLISH EDITION.

In laying a version of M. Ville's last work before the British public the Editor wishes to point out that it resolves itself into two portions, interwoven with each other, but so distinct in their purport that the one may be accepted without approval of the lessons of the other. The purely technical, agricultural part of the work is an admirably clear and luminous summary of the teachings of M. Ville's larger work, 'Artificial Manures' (Longmans and Co.) It contains much additional practical evidence on the successful working of the author's system of artificial manuring. The theory of 'dominants' is enforced by actual experiments carried out not only in France but in other countries. The use of the plant itself to effect the analysis of the soil is well explained.

As a specimen of the experiments bearing on this important point we cite a portion of a pamphlet published by M. P. de Bilderleig, a Russian nobleman who takes a great and active interest in the advance of agriculture. He writes:

'Last year there appeared in our periodical press treating of agriculture a paragraph to the effect that M. G. Ville, the eminent French agriculturist, director of the experimental field of Vincennes, promised to publish shortly a manual concerning the means of defining the chemical composition of the soil which produced plants according to their external characters.

'The promise was attractive. The studies of M. Ville are sufficiently known; his theory of chemical manures, his first origination of experimental fields on purely scientific principles, and, lastly, his theory of sideration, which has attracted so much attention among us, are estimated at their just value by all those who interest themselves in agricultural questions.

'In a series of articles inserted in the "Revue Scientifique" (December 1889, February and May 1890), M. Ville published the results of his researches on the development of vegetation under the influence of, and in dependence on, the composition of the soil.

'These articles are entitled "Analysis of the Soil by Plants." They represent a method as novel as unlooked-for of investigating the phenomena of the inner and outer life of plants, and may justly be regarded as the commencement of a new era in our practical knowledge of the elements of the soil.

'This is what was said by M. Stanislas Meunier in his report of the meeting of the Academy of Sciences at Paris on July 21:—

'"It was in the midst of the sustained attention of his hearers that Professor Ville communicated the remarkable results to which we are led by the use of plants as reagents concerning the composition of the soil upon which they have been developed. The facts in question have indeed considerable importance from a practical point of view, as well as from that of pure science, and we may say that the learned author opens up a new way for researches in vegetable physics."

'I add on my part, as an admirer of the experimental method adopted by M. Ville for the solution of questions concerning practical agriculture, that the researches and the results to which he has been led represent by their practical consequences a scientific study of exceptional value. We may boldly say that they are like the rare achievements which are marked in the annals of science and of practical life by a brilliant train of light, and that they must rank among those conquests of the human intellect which form epochs in the development of natural science.

'The translation of the researches of M. Ville has unfortunately not been published in our periodical press, on account of the difficulty of reproducing the diagrams, without which the conclusions of the author are deprived of the evidence in which their persuasive power justly lies. This has forced me to publish this study in the form of a pamphlet. The question of the necessity of organising agricultural experimental stations having been raised also among us, we may hope that the propagation of indications so useful and practical as the method inaugurated by M. Ville will be favourably received.

'In conclusion I will permit myself further to quote certain interesting facts drawn from the same Compte Rendu of the Academy of Sciences, which illustrate the scientific labours of M. Ville, concerning the definition of the degree of sensibility of living organisms to phosphoric acid.

‘Thus, for instance, in the cultivation of wheat in pots with two grammes of calcium phosphate to 1,000 grammes of earth, we have a luxuriant development of the plant, whilst with one centigramme only of the same phosphate the vegetation becomes feeble, sickly, and perishes visibly. In this case the plants with large seeds—for instance, peas—possess a remarkable peculiarity, for they contain in their tissues a notable quantity of calcium phosphate. Even without an addition of the salt the plant flowers and ripens; but if we sow them in a soil devoid of phosphate, we see the second generation of peas succumb to inanition.

‘In spite of the great delicacy of the explanations communicated, M. Ville has found means to realise experiments still more astonishing on the divisibility of matter by the study of the various degrees of energy with which the yeast of beer induces the transformation of sugar into alcohol according to the composition of the saccharine fluid. We quote the words of M. Ville himself:—“With two ten-thousandths of phosphate in proportion to the weight of the liquid the fermentation lasted 306 hours, 30 grammes of sugar disappeared—i.e. 120 times the weight of the phosphate. With five millionths of phosphate the fermentation lasted

1,004 hours; the quantity of sugar disappearing rose to 5,000 times the weight of the phosphate. Lastly, with five ten-millionths of the weight of the liquid 17·28 grammes of sugar had disappeared—i.e. 3,700 times the weight of the phosphate employed. If we entirely suppress the minerals and the phosphates, the fermentation is manifested only by effects barely perceptible. The yeast lives upon its own substance. The quantity of sugar disappearing was 1·123 grammes, which required 640 hours; but from this moment the fermentation was completely arrested."

'From the foregoing facts it results, if we mention only the two extreme terms, that if with wheat we have been able to detect in calcined sand one ten-thousandth of phosphate, shown by a weight of crop equal to 600 times the weight of the phosphate, with beer yeast we are able to recognise by a series of gradations the presence of 0·0005 gramme of phosphate diluted in a litre of water, which corresponds to five ten-millionths of the weight of the liquid; and the quantity of sugar which has disappeared is 34,000 times the weight of the phosphate indispensable for the vital manifestations of the yeast.

'According to the opinion of M. Ville, the sensibility of vegetable organisms for phosphate is a proof that plants regarded as reagents are much more exact and sensitive than all the procedures hitherto known. He takes as example the sugar-cane, for which calcium phosphate is a predominating manure. If the chemical manure is complete, the crop reaches 57,000 kilos. per hectare. If we exclude the phosphate from the soil, the crop falls to 15,000 kilos.; whence it results that 600 kilos. of superphosphate, containing 90 kilos. of phosphoric acid, suffice to raise the yield by 42,000 kilos. per hectare, which represents 466 times the weight of the phosphoric acid employed.

'I presume that the facts mentioned suffice to prove that plants regarded as simple reagents possess a great certainty in their indications, and are endowed with a high degree of sensitiveness.

'It only remains for me to add that on the experimental field on my estate I have had opportunity in the course of this season to verify upon the same plants the infallibility of the method proposed by M. Ville for defining the composition of the soil. I do not doubt that the agriculturists concerned will find in these researches precious indications for the systematic observation of plants, a guiding thread to the knowledge of the qualities and the defects of the soils which they cultivate.

'P. DE BILDERLEIG.

'ZAGROLIE:
'*September* 1890.'

As regards the manner in which the nitrogen of the atmosphere is appropriated and utilised by certain classes of plants, M. Ville writes on June 15 last:

'Two experiments on a mixed cultivation of hemp and clover are sufficient to refute all the objections which have been made on the assimilation of nitrogen by the microbia of the soil, which possess, it is said, the property of fixing in the soil nitrogen which is rendered assimilable by the mere fact of its fixation.

'Experiment No. 1 shows that the nitrogen of nitrates is beneficial to hemp but injurious to clover.

'Experiment No. 2 shows that in the absence of nitrogenous matter the hemp is miserable but the clover splendid.

'But if there are microbia which enrich the soil with nitrogen at the expense of the nitrogen of the atmosphere, so that such nitrogen becomes assimilable by the fact of its fixation, how is it that hemp does not show the intervention of this nitrogen, as in experiment No. 1, where nitrate has been given to the soil?

'As the soil of the pot No. 2 has received phosphate, potassa, and lime, if the microbia can effect the addition of nitrogen the fertility of the soil ought to be much increased and the hemp ought to show its intervention. But this does not take place. Hence the power of assimilating atmospheric nitrogen depends on the specific nature of certain classes of plants.'

The author's remarks on the possible future utilisation of a part at least of that immense amount of *vis viva* which is poured upon the earth day by day in the sun's rays, but which is at present wasted, are profoundly suggestive. An inventive mind, applying itself to agricultural problems, may perhaps here find a true method of dealing with the dangers of over-population, and cause food to increase as fast as, or even faster than, its consumers.

So far M. Ville's teachings are applicable and valuable to all countries. We may, indeed, doubt whether he does not assign a higher rank to lime, especially in the form of gypsum, than English experience and observations drawn from the natural distribution of plants on different soils would justify. But by refuting the old fallacy that organic matter by being passed through the bodies of animals acquires some mysterious value which it did not possess before, he has done incalculable service. It is sad that in these days there can still exist recognised agricultural authorities who can advise farmers to buy 'good feeding-stuff' rather than superphosphate, salts of potash, and ammonia or nitrate.

M. Ville shows, moreover, how farmyard dung may be modified so as to suit the requirements of different crops. At the same time he is fully justified in comparing the farmer who buys cattle in order to have a supply of dung to an ironmaster who should plant and maintain forests in order to procure fuel.

The other portion of M. Ville's book is of a very different character. In order to show the importance, or rather the necessity, of the agricultural reforms which he advocates, he enters upon economical and political questions. Much of what he says is totally inapplicable to English conditions, and much more—e.g. heavy duties upon the importation of wheat and cattle for the relief of native agriculture—would be at once rejected. His dread of American competition in the production of wheat seems to be in part founded upon a mistake. As the population of the United States becomes denser —and he declares that it doubles itself every twenty years—they will have less and less food to export, whilst the price of land will rise. The same will be the case in the other 'new communities' whose exportation of food he views with alarm. But this prospect, instead of weakening M. Ville's arguments for agricultural improvement, strengthens them. If France, England, &c., can no longer import wheat, the more necessary it will be for them to raise their native production to its possible maximum.

His views on emigration from Europe are scarcely sound. If every man who emigrates has cost his native country 8,000 francs, his departure will not be a loss but a gain, unless he can support himself at home without having recourse to charity, private or public, or to crime. In America the immigrant is much less welcome than he was formerly.

It is curious that whilst in England many politicians are anxious to create a class of peasant land-owners, in France, where such a class has existed since the Revolution, their presence has been felt as a bar to improved farming. How can a man who owns a quarter of an acre use the steam plough or buy the necessary manures? M. Ville protests against the present law of inheritance, which in France, on the death of a landowner, compels the equal distribution of his estate among his family, and thus leads to the ever-increasing subdivision of the land. He mentions among the burdens pressing upon French agriculture the military laws. We must remember that the enormous armies of the present day and the universal conscription rank among the most striking legacies of the Revolution.

The author thinks that agricultural improvement in his country would place England in dependence on France. This is a misconception. Our wants are supplied from other countries, and before France can rule our markets she must be able to under-sell Russia, Canada, Australia, and India, where, as he tells us, wheat is produced at three or four francs per hectolitre. Neither must we forget that other countries will learn M. Ville's lessons quite as rapidly as does France.

Nevertheless, we shall do well to bear in mind that no country is on a safe footing so long as it cannot supply food for its inhabitants. A number of causes, impossible to foresee, may at any moment involve it in misery and humiliation.

PREFACE
TO
THE FOURTH EDITION

I.—1884.

I MUST truly beg pardon of the economists who have been so amiable as to see in the severe trials which agriculture is at present undergoing an ephemeral crisis, which, they say, will die out spontaneously without apparent cause, just as it began; in my humble opinion this is not the true position of affairs.

What I said at Rouen in 1879, at a public meeting which was not without its echoes, I may now repeat with more confidence, as facts have justified all my previsions.

I said:

'It is wrong to believe that we are merely passing through a momentary crisis; there is in the situation something much more grave. We are at the opening of a conflict which is destined to change the economic conditions of Western Europe, the prelude to the competition which cannot fail to spring up some day between Western Europe and exotic communities.

'It is a struggle, pacific if we please so to call it, but which will not come to an end. Its means of action are public and private initiative, labour, national activity in all its forms. It is a conflict far more redoubtable than war carried on with weapons, for it is no question of merely losing or winning a battle. Public prosperity, the decay or the fall of the entire country are at stake. What I say of France I might apply to the rest of Western Europe.'

How are we to meet the effects of this situation, so pregnant with dangers? There are no two methods, there is only one: we must transform our ancient methods of cultivation, extend the duration of leases, create institutions of credit which may supply the capital needed by those who are working the soil; but before and as a preliminary measure we must support agriculture by a system of compensatory imposts, without which the struggle is impossible.

Let it be understood that this act of national recompense must be immediate!

To those who speak of depending on the pacifying action of time and on private enterprise I would reply by this parallel between France and America:

America receives a yearly mean of 400,000 to 500,000 immigrants, who have cost their native countries not less than 8,000 francs each; 400,000 immigrants represent therefore a money value of 3,200,000,000 francs in the shape of the most perfect instrument of production.[1]

But this is not all! It is estimated that each immigrant brings with him a sum of from 500 to 1,000 francs. For 400,000 immigrants this is an increase of wealth of from 200,000,000 to 400,000,000 francs. Total: four to five milliards under the head of immigrants.

In the United States the land is worth fifteen francs per hectare. Prairie land is worth twenty to twenty-five francs. There is no rent for the soil.

---

[1] It must not be forgotten that, whatever it may have cost to bring up a man, he is of a *minus* value in the country where he lives if he is supported by public or private charity. The emigration of such a man is not a loss, but a gain to his native country. He is a gain to the country to which he goes only if there is there an effective demand for labour.—[EDITOR.]

There is no army and no navy. The entire youthful population is concentrated upon productive labour.

Cultivation is practised upon immense areas where there is free scope for mechanical improvements. For transporting merchandise there are navigable rivers comparable to inland seas, which permit of exportation without transhipment. The population doubles itself every twenty years. The territory is capable of nourishing 500,000,000 men, under a relentless prohibitive system receiving nothing from us without import duties, and inundating us with a part of its surplus sufficient to disturb the total economy of our inland production.

Let us now turn to France. The land is worth here on an average 2,000 francs per hectare, and it is let at from fifty to one hundred francs.

As to the constitution of the proprietary, reflect upon these figures:

Cultivated area, 46,000,000 hectares, divided into 143,000,000 plots represented by 14,000,000 ground-rents (?), which gives as a mean one-third hectare for the area of each plot, if we include the great estates in the grand total, but only one-eighth hectare if they are excluded.

Add, to complete this picture, another statistical result:

Among the 14,000,000 plots taxed there are:

Two millions at 10 to 20 francs.
Two millions at 5 to 10 francs.
Seven millions below 5 francs.

That is in all 3,000,000 proprietors are exempt from taxation on account of indigence.

What system of cultivation can he follow who has to make the best of eight or ten plots of the sixth or the tenth of a hectare?

Add to these disadvantages our military law, our heavy imposts, the absence of all freedom of action for the farmer, seeing that Article 2102 neutralises any advantage the proprietor might derive from live stock, the most defective register of lands of all Europe, taxes on the transfer of lands which absorb three years' rents, and lastly the absence of credit for agriculture.

As a most deplorable evidence our population requires 190 years to double itself, whilst it is doubled in fifty years in the other countries of Europe. In France there are forty-eight departments where the population declines in place of increasing.

I ask once more, What must we do?

We must arm ourselves as quickly as possible for the struggle from which we cannot escape. Science has done its work; it is for policy to take its share.

The means of increasing our production have in them nothing mysterious; but to apply them we have need of a system of reforms and creations which cannot be improvised, and whilst waiting until we are ready we need a temporary import-duty upon corn and cattle. In 1879 I fixed this duty for corn at three francs per quintal, and at thirty francs per head for horned cattle. At present these figures would be insufficient. They must absolutely be raised to eight francs per 100 kilos. of wheat, and eighty francs per head of horned cattle.

Are these features, I ask you, the characters of a simple ephemeral crisis?

Let us not, therefore, speak of free trade! Free trade and protection correspond to two different states of the productive power of nations. One and the same expedient may be good here, but detestable elsewhere; if excellent in 1860, it may be ruinous in 1884. It is a simple question of convenience and suitability. All the resounding theses of twenty years ago have had their day. What is now our pressing duty is the obligation of securing national safety. A nation should so husband her resources as to be self-supporting and to remain mistress at home under all contingencies.

If England has been able, thanks to her coal-mines, which for a century have made her island a workshop actuated by steam, the production of which is not less than the manual labour of 300,000,000 to 400,000,000 men; if England has been able, thanks to the accumulated wealth of centuries, to attain a degree of prosperity unequalled by other nations, the day is perhaps not far off when she will learn to her cost that such a constitution is fragile, and find to what immediate reverses of destiny are exposed all nations who do not produce sufficient for their maintenance upon their own soil.

II.—1890.

I was far from foreseeing in 1879, when I demanded high protective measures to give France time to organise the struggle against alien importation, that events would so quickly prove me in the right.

In fact, America has just openly declared her wish to break off commercial relations with all the States of Europe or to enslave them.

The McKinley Bill, voted at once by the Congress and the Senate, has become law. All foreign industries without exception, besides an enormous increase of duties, are given up to an inquisitorial system of suspicion, which inevitably ends in prohibition under pretence of a false declaration to the Customs or fraud as regards the quality of the products. Add that importers are permanently liable to heavy penalties and even to imprisonment.

This is not all: the President is armed by the same Bill with the uncontrolled right to suspend, by a simple proclamation, and for as long as he may think fit, the importation of all products or of any product from any country if he is of opinion that an arbitrary or vexatious measure has been taken in such country against a product of American origin.

Who would have believed in 1879, at the time when people persisted in seeing in the trials which agriculture then experienced the mere effects of an ephemeral crisis, that new countries would in less than ten years arrive at procedures of such a character?

Protection, therefore, is forced upon us as a measure of national safety; but what I said in 1884 I repeat, with increased emphasis—protectionist measures are, and cannot be anything beyond, an expedient. The necessary solution which imposes itself upon us is the radical transformation of the old systems of cultivation, founded upon dung, into the new system, founded upon chemical manures and sideration. Dung can be henceforth but an appendage in the cultivation of the soil. We must have protective duties, and very high ones; but the progress of the methods of cultivation, and the improved constitution of property, will render them useless in less than ten years. We shall preserve them to guard against surprises, but in reality we shall be able to dispense with them by the development of production. Admit as a simple supposition that production increases in France by thirty per cent. on wheat, meat, potatoes, hemp, and flax, and by fifty per cent. on wine, sugar, and fruits. What then could the hostile Bills of America do against us? But how, on the contrary, would the condition of our population be improved? Two words tell it: cheap living in superabundance, prosperity and security for the country, and towards the foreigner the proud attitude which neither menaces nor fears anyone.

In those days the producer will not be worse remunerated, because he will find in the increase of his crops the compensation for that reduction of prices which the working classes justly claim. To obtain this result, it will suffice to apply to three or four million hectares devoted to the production of cereals from 100 to 150 francs worth of chemical manures per hectare, and sixty to eighty francs worth to our meadows and pastures.

The efficacy of the means cannot be disputed; our production of cereals has increased in a few years from fifteen to twenty hectolitres, and this is due to chemical manures. Generalise the procedure, and the end will be obtained.

France will have conquered the three factors which make the prosperity of nations—security, cheap living, and the most complete independence of the alien.

But I cannot too often repeat, in order that agriculture may arrive at such a result, the public authorities must comprehend that technical progress will remain a dead letter without a defined political and social system.

In this respect certain great measures cannot be delayed:—

A grand measure demanded by the agricultural evolution is the reconstruction of the register, which is the most defective in Europe.

The register ought to be essentially a modern Domesday Book, a safeguard of the interests which it represents; but to this end the territory must be entirely covered with outside limits marked by a general triangulation, and the individual lots must be inscribed under an unchangeable number, which renders it possible to follow the changes and the divisions which each of them may undergo. In other words, the inscription must be made in the name of the plot, and not in the name of the proprietor. This is the inverse of what now exists, which is an exhaustless source of disputes and lawsuits, and an attack on that security of title which is the affirmation of property.

What renders the reform of the register so desirable and so pressing is the natural opportunity which it would offer to effect by way of exchange the reunion of the scattered plots, and to establish gratis, on behalf of the small domains thus agglomerated, a right of property in full form for the cost of a simple stamp.

Add as the crown of this transformation of property what Leplay and his school demand with such persistence—the liberty of bequest, to raise the authority of the father of the family, and to protect the family home—and you will have realised the cardinal conditions which would make of France a great and powerful democracy.

Ask yourselves what would be to-day our situation in the world if the increase of our population, favoured by a better management of our productive forces, was 300,000 head per year, or if it had been only maintained at the figure of 200,000, which it had reached in 1847; if only a truly national primary instruction had initiated it from infancy in the duties of the citizen, and in the practical exercise of public liberties—as, e.g., has been the case in Switzerland, which has latterly given such imposing evidence of its energy to defend its independence against the foreigner and its rights against itself.

Follow out this chain of deductions, and ask yourselves what might be drawn from the soil of France if, property being better arranged, there was distributed simple, precise, and practical information throughout the country on the use of fertilising agents according to the prescriptions of science. When my thought calls up these eventualities I feel myself pervaded with a faith which rises to enthusiasm.

What, tell me, would become in face of these prospects the fear of foreign competition? Defective crops would become legendary.

But do not let us lose out of sight that all this has for its cause the progress of science during this century, and in particular the discovery of the laws which govern vegetation, which is the first instrument in all our acts of production. Let us add that in this domain the discovery of the assimilation of atmospheric nitrogen by plants will mark one of the greatest evolutions which human industry has yet experienced.

This discovery belongs to the scientific patrimony of France, and the hour approaches when, after forty years of passionate denial, no voice, not one, will dare to raise itself in opposition. Putting intentionally aside all personal claims, I confine myself to set up this landmark of expectation.

In the sphere of practical applications these three lectures will have furnished the first assertion of the unhoped for advantages of sideration, and given the first formula of the new methods of cultivation to which the present will owe its prosperity and the future independence and security.

GEORGES VILLE.

LE GRAND-BILBARTEAULT :
September 6, 1890.

PREFACE

TO

THE FIRST EDITION

NEVER to my knowledge has agriculture traversed a period of trials comparable to that which it undergoes at this moment, and which is unfortunately merely the prelude of the competition between Western Europe and countries more favoured than ourselves as regards climatic and social conditions.

This unprecedented situation compels us to transform our old systems of cultivation.

I have expounded in these three lectures the most proper means, to my knowledge, for attaining this end; and, in order to give more force to my demonstration, I have collected in the Appendix the results of a great number of experiments which for the most part have remained unpublished.

The lectures are due to the initiative of the Royal and Central Agricultural Society of Belgium, the benevolent confidence of which towards me has been unceasingly manifested.

The adhesions which have followed have earned for me two very precious testimonials: the title of Doctor of the University of Louvain, and the Cross of the Order of Leopold.

I recall them here to have the opportunity of expressing my sense of the respectful gratitude with which they have filled me.

GEORGES VILLE.

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INTRODUCTION

In the last week of December 1888 M. Georges Ville gave three agricultural lectures in the hall of the Academies at Brussels, at the request of the Royal and Central Society of Agriculture.

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The first lecture took place on December 18. At half-past two M. de Cannart d'Hamale, President of the Society of Agriculture, assisted by MM. van der Straten Ponthoz, Chevalier de Menten, L. T. Sertevens, Vice-President of the Society, and M. Proost, the Secretary, entered the hall.

The President, addressing M. Ville, whom he introduced to the meeting, bade him welcome in the name of the Society of Agriculture, and, after thanking him for the inconvenience to which he had submitted in meeting the wishes of the Society, called on him to speak.

M. Ville heartily thanked the President for the flattering language addressed to him, and then, turning to the audience, he spoke as follows:—

FIRST LECTURE

AGRICULTURAL PRODUCTION

Gentlemen, in the life of each of us there occur serious moments. For a general, the serious moment is that preceding the battle. My position at this moment is precisely similar.

I come in your midst to engage, not in one battle, but in two, or perhaps three.

The armies of the conquerors of the past counted scarcely hundreds of thousands of men. My army is counted by hundreds of millions, not to say milliards. It includes in its artillery the sun, the water, the earth, chemical affinity, and electricity, of which thunder is a manifestation.

This army does not scatter devastation in its track; it does not leave behind it orphans and widows; but, being directed by human science, it becomes the chief agent in the well-being of the people and the wealth of nations.

When left to themselves and restricted to the vegetable kingdom these powers form the virgin forest and create splendour in chaos. But when they work along with human labour they produce our fields, our harvests, and the pastures for our numerous cattle.

It is the part which each of these elements takes in the agricultural result which I wish to explain to you.

It is the play of these forces which I am about to define, laying aside the empirical precepts which the past was obliged to obey without being able to explain. In other words, it is intelligence gaining a knowledge of the laws of nature, so as to substitute in the most effective manner the work of the brain for the work of the hands.

This, gentlemen, is the object of these lectures, or, if you prefer it, the first battle in which we must engage.

How is it that I have been led to give to the agricultural problem this character and this scope? For thirty years I have imposed upon myself the task of defining practically the *rôle* of each of the elements which enter into the composition of plants, so as to produce a plant by their aid in an inert medium.

On this very spot I endeavoured, ten years ago, to throw light upon problems which become more and more pressing in consequence of the increase of our population. I may say without ostentation that the universal practice of the agricultural world has endorsed the results which I laid before you.

At present the economical situation of Europe is more serious than it was ten years ago.

Each year it loses by emigration a million of its most robust children, who go to fertilise the soil of the new worlds, and lay the foundations of a competition which oppresses us, but which we are powerless to oppose.

What a spectacle is presented by our markets and our rural districts! Here corn and meat are selling at an unremunerative price, and there rents are reduced by one half.

Who does not know that Belgium—to take her as an instance—loses about 200 millions (francs) on her rents, corresponding to an equivalent loss of profit on the part of the cultivator, of 400 millions annually? France herself, a land predestined to prosperity and abundance, sees her farms abandoned.

In a situation so threatening, it seems to me that the savant has no longer the right to remain shut up in his laboratory; that his duty calls him to the field of honour, to seek out the causes of the defeat with which we are menaced, and submit personally to sacrifices which he would otherwise shun. I considered it my duty to undertake at my own cost and risk large agricultural operations, if only to know whether—thanks to new methods of culture, and by supplying to the soil the capital which is generally lacking—I could not work by proxy, as in manufactures, and give to our rural undertakings an organisation powerful enough to hold its ground against the alien.

But what was the surprise which I experienced at my very first step !

The methods which it was necessary to apply are so simple, and so thoroughly confirmed by experience, that I foresaw no obstacle.

I had not reckoned on the hostility of the rural masses, whose coarse and insatiable greed Balzac has so truthfully painted. At my very first steps I encountered unforeseen resistance, secret coalitions, treacheries, culpable if not overtly criminal. The universal hostility of my surroundings finally paralysed my means of action. Will it be credited that, in spite of all my efforts, I have not been able to produce with advantage the harvest which the agricultural practice of all nations has for twenty years realised by following my indications; and that, finally, for whatever I could do for the solution of a problem of science and of agricultural practice there was gradually substituted a dogged struggle, without truce and without mercy, against the frauds, the betrayals, and the strikes which surrounded me on all sides?

Upon surprise followed anger, a bad counsellor even when legitimate; for the occurrences had wounded me in one of my deepest and most disinterested sentiments. But, by a fortunate compensation, the end being beyond control, I was able to pursue my work, and the result was in my favour.

I sought at first to overcome the obstacle with silver weapons—a procedure similar to that of Darius, who wished to chain up the ocean. The obstacle was too strong for me. Now I am no longer irritated. I feel no resentment against anyone, I was ignorant; I understood the agricultural problem only under one of its aspects; the other was unknown. When once a light on this point dawned upon my mind I resolved to eliminate from the disturbing influences results which might affect them, so as to draw certain financial conclusions.

I have ceased to view my agricultural operations as anything but an instrument of experimentation.

I then applied myself with all the energy of which I was capable to take hold of the practical problem, to define it in all its terms, and to leave nothing unknown without gauging its importance. Am I right? I believe so. I am about to ask you to decide.

I repeat, the object which I wish to reach is to indicate to the landowner, forced against his will to become a cultivator, how he may carry on the struggle to advantage; by what means he can become a farmer, and by what developments of the same means the farmer may make his fortune; so rigorous is the sequence of the new methods, and the result so certain.

What, gentlemen, is the starting-point of agricultural production? Here no hesitation is possible—it is the plant. From the plant is derived the animal. The agricultural industries themselves are merely derivatives of the vegetable or the animal kingdom. We therefore begin with the plant.

You ask, therefore, of what the plant is formed, and how it is constituted. To this question the past had an answer cut and dried. It said to you, The plant is derived from farm-yard manure. To have good crops, you want much manure; and to get manure, you need meadows and cattle. Unfortunately, it was added, cattle are a necessary evil to which we must submit. What a progress it would be if we could be freed from the cattle and the meadow which serve to yield farm-yard manure!

It is not thus that we look upon the question. We say to ourselves simply, Science has succeeded in reproducing artificially the minerals which constitute rocks. Why cannot the same result be obtained with the plant? Why admit that there are unfathomable mysteries in its formation? In what does a mineral differ from a plant? It is, that the plant has for its point of departure a seed, and that in this seed there is an embryo; that this embryo is the seat of a special force in a latent state, which is capable of manifesting its activity if placed in certain given conditions. Why can we not succeed in producing a plant in a soil of calcined sand if we add to this sand the substance which analysis enables us to detect in plants grown on a good soil?

Let us follow out the consequences of this point of view.

All vegetables, without distinction, be they tree, plant or moss, show in their tissues the presence of fourteen elements, always the same. The fourteen elements are here enumerated:

Organic Elements

Carbon
Hydrogen
Oxygen
Nitrogen

Mineral Elements

Phosphorus
Sulphur
Chlorine
Silicon
Iron
Manganese (?)
Calcium
Magnesium
Sodium
Potassium

But here arises a question. You ask me, Do food-plants and poisonous plants owe their formation to the same elements? This is, indeed, the most exact truth: fourteen elements—always fourteen—produce poisonous plants, food-plants, perfumes, dyes, &c.; in a word, the totality of vegetable substances. How is such a result possible? The work of a printing-office will give you the explanation. A language is composed of many thousands of words. In what manner are these words formed? For us, with twenty-six letters combined in various manners. Very well, the vegetable kingdom is like a language of which each plant is a different word and of which the fourteen elements above mentioned are the alphabet. The properties of plants do not depend on the nature of the elements, but on the different order in which they are combined. Here there appears an abyss between the formations of the vegetable and mineral kingdoms. To form the 5,000 to 6,000 minerals known there are required seventy different elements, grouped by fours, fives, or sixes; whilst to form the 200,000 or 300,000 plants of which the vegetable kingdom consists there are needed merely fourteen; but these fourteen elements are never separated, and occur in all plants inseparably. What determines the properties of a mineral is the changing nature of the elements; whilst in the plant it is the method of grouping. But there is a further distinction between plants and minerals. In a mineral all the elements are movable, and we can displace them at pleasure. Here in this glass is a solution of mercuric chloride, a compound formed of mercury and chlorine. We wish to displace the chlorine. This is easily done. We need merely to pour into the solution some nitrate of silver. The chlorine combines with the silver, forming a white precipitate, which renders the liquid turbid, and finally settles to the bottom of the glass; it is silver chloride.

Or, on the other hand, we may wish to displace the mercury. Nothing is easier: we have merely to substitute for silver nitrate, potassium iodide. In that case the iodine combines with the mercury, and forms the splendid scarlet precipitate which is produced before your eyes. The mercury can thus be displaced at will, and takes the new form of mercuric iodide. But try to displace in a vegetable tissue the carbon, the hydrogen, the oxygen, or the nitrogen; it is impossible. The substantial unvarying basis which constitutes plants, when once formed, possesses an irreducible power of aggregation. You may certainly by analysis isolate everything which exists in a plant, but it is under the absolute condition of destroying it without recovery. You cannot displace the elements of a plant and still preserve to the system its form and its integrity.

This is precisely what distinguishes plants from minerals. Over minerals our power is unbounded. On organic compounds, the products of life, the seal which has been impressed upon them is indelible. The plant says to us: I am mightier than you. You may analyse me, you may decompose me, but you cannot change my texture.

We have said that in all plants there are fourteen elements, always the same, forming a constant, unvarying foundation. But these elements have very dissimilar properties. In virtue of this dissimilarity we may divide them into two categories: the organic elements and the mineral elements. The organic elements are represented by carbon, hydrogen, oxygen, and nitrogen. The mineral elements are ten in number. To separate the organic elements from the mineral elements, it is merely necessary to burn the plant. Combustion dissipates the organic elements in the state of smoke, vapour, and gas. It leaves, on the contrary, the mineral elements in the state of ashes. If left to itself a plant is decomposed; after a few days the texture of its tissues vanishes. In place of this plant there remains a heap of black matter without organisation, the weight of which incessantly decreases.

In this work of spontaneous decomposition we see the same changes effected slowly which combustion produces with more rapidity; the organic elements escape as gases, and the mineral elements are finally left as residues.

We have now arrived at three or four fundamental propositions. I must beg you, gentlemen, to be patient. The practical results cannot be made clear unless we explore, in a theoretic form, the region of vegetation in its whole extent. If

I were to suppress the theoretic form the science would no longer exist. As for the laws, you would not be able to grasp them, and we should remain in the sphere of rule-of-thumb and of recipes. But an agriculture founded upon empiricism and upon recipes no longer suffices for our wants.

Let us pass, therefore, to a new order of considerations.

We ask whence come the organic elements and the mineral elements of the plant. Science answers that the mineral elements come from the soil, and that the organic elements come from the air and the water.

Take as an instance wheat. Its composition is known to be as follows:

Carbon	47·69	93·55 per cent. obtained from air and water.
Hydrogen	5·54	
Oxygen	40·32	
Soda	0·09	3·386 per cent., with which the soil is superabundantly supplied, and which do not need to be restored to it.
Magnesia	0·20	
Sulphuric acid	0·31	
Chlorine	0·03	
Oxide of iron	0·006	
Silica	2·75	
Manganese	?	
NITROGEN	1·60	3·00 per cent., with which the soil is supplied only in a limited extent, and which must be furnished by manures.
PHOSPHORIC ACID	0·45	
POTASH	0·66	
LIME	0·29	
TOTAL	99·93	

In one hundred parts, therefore, there are ninety-three parts which the earth has not given. Hence if the earth has no furnished them there is no occasion for you to restore them. These ninety-three parts are derived from natural sources, inexhaustible, always available, and which nature .places constantly at your disposal. In what manufacture do things take place in this manner?

Choose whichever you please—metallurgy, weaving, spinning—and you will always find that the finished product represents only a portion of the raw material committed to the machinery. There is always waste. Here, in agriculture, the course is different. You obtain more than you have employed. Consequently there is an absolute contrast. Agriculture gives more, manufactures yield less. Let us follow the consequences of this contrast.

Among the mineral elements, of the ten found in the plant there are seven which you do not need to supply to the soil; it contains them just as the sea contains salt; there is, therefore, no need to offer to it what it already possesses in superabundance. From elimination to elimination you arrive at this conclusion, that all plants are formed of fourteen elements invariably united, and that if we restore to the soil the nitrogen, the phosphoric acid, the potassa, and the lime which the plant has taken away, it will never become exhausted. The earth continues to return fourteen if you give it four. It realises the mystery of the multiplication of the loaves, and agriculture remains the only creative industry.

Manufacturing industry properly so called transforms; agriculture creates, by drawing from the sources of nature, which are always open, by means of the four bodies which must be supplied to the soil. When it has received them they command the air and the rain. They force the carbon dioxide of the air and the water which soaks into the soil to fix themselves in plants. In the absence of these four bodies, there is no vegetation. To know them is to possess the virtual conditions of vegetable life, which, thanks to them, we can transport just as we can convey mechanical power on a wagon loaded with coal. These four substances are in reality the equivalent of plant-life in a latent state. In them there exists the *vis viva*, which controls vegetation, and this force has been conquered by the intelligence and the necessity which incessantly impel man to secure and to elevate the conditions of his existence.

The practical consequences are splendid. Here we do not confront a theory but an indisputable fact: with four you can produce one hundred. Each of us can cause a plant to grow in sand which has been ignited; the industry of chemical manures is constantly increasing, and agricultural practice is ready by the successes which it has obtained to maintain the truth of the theoretical notions to which this industry owes its origin. The period of idle discussions is at an end.

Let us stop at this assertion that substantially with four we can make one hundred, and that with the help of four bodies we may produce vegetables containing fourteen.

We must establish the economic bearing of this twofold assertion.

If we allow for carbon the price of coal at Paris, i.e. forty francs per ton, and for nitrogen the value which it bears in manures, i.e. one and a half franc per kilo., we find, with reference to the agricultural territory of France, that what vegetation draws from the air is not less than five milliards yearly, represented by sixty million tons of carbon, and eighteen hundred thousand tons of nitrogen, distributed as follows:

—	Surface in hectares	Carbon absorbed (tons)	Nitrogen absorbed (tons)
Arable and meadows .	30,659,254	41,910,000	1,530,000
Forests and vineyards . . .	9,766,334	18,320,000	350,000
Olive, almond, and mulberry gardens .	109,261		
Chestnut plantations	559,029		
Total in tons		60,230,000	1,880,000

So far everything has been simple and impressibly evident. But in the agricultural problem there is another order of ideas, more difficult to penetrate and to seize, and which at first sight seems without possible application. This is what I will call the potential part, in opposition to the substantial part, which has occupied us hitherto.

Every act of production requires for its accomplishment two necessary conditions: a primary matter and a force or energy; the matter which receives the force, and the energy which gives it.

But, in agriculture, whence comes the force which yields the crop? Is it from the labourer?

When he ploughs, harrows, and sows does he make the crop? No. He prepares the soil so that the plant may develop itself. But there his action ceases; the instrument of production in reality is the plant; and this plant—how and by what is it animated? A very simple experiment will teach us. Here is a conical mirror, in the centre of which is placed a boiler actuating a small machine and converting it into a steam-engine of four to five horse-power. The sky gives its radiations, the machine enters into motion, and furnishes useful work. In Egypt, in Algeria, where the sky is always serene, in Chile and Peru, in the midst of deposits of sodium nitrate, where fuel cannot be procured for less than 200 to 300 francs per ton, these machines are being adopted. What is the lesson which they teach? The sun is the furnace of the system; the mirror is the recipient which concentrates its effects; the boiler is the medium which utilises them. Hence we conclude that the rays of the sun are here transformed into mechanical work. If we substitute for the solar machine a plant the effect produced is quite different. When the rays of the sun fall upon a leaf, the leaf absorbs the heat and light formerly reflected by the mirror. It extinguishes them, but this does not mean that it destroys them. The heat and the light are embodied in the substances which the leaf has drawn from the air and in those which the roots have drawn from the soil. The heat and light thus pass into the state of chemical affinity. What was soil, what was air, what was water, what was dead matter become organised matter. Dead matter enters into the domain of the living, where by successive transformations the vegetable substance consumed by animals disappears whilst giving out heat and motion, and thus from step to step finally animates ourselves.

What is the quantity of *vis viva* derived from light, from the solar radiations, which plants consume? At least 8,000 horse-power days per hectare, or, if you prefer it, the equivalent of 40,000 human days' work. Here the agricultural problem appears in all its grandeur. And what will surprise you much more is, that from these data will be evolved in the third lecture the most practical and the most economical methods of cultivation. These procedures yield, in fact, a saving of fifty to sixty francs per hectare on the preparation of the soil, and of 100 francs per hectare on the price of the manure intended to maintain its fertility.

Let us endeavour clearly to understand and to define these ideas. They are unexpected. Whatever our wishes may be, the world moves on. Each year, almost each day, brings its contingent of useful discoveries painfully conquered; for progress, as history attests, is bought only by suffering.

And if the discoveries in question are destined to so great a future, it is that by their means we may produce with more economy, and in greater abundance, the nutritive substances destined to become part of our own bodies; thus securing the virtual and primordial conditions of the prosperity of the nations, which guarantee the existence of each of us. Whatever difficulties we may meet on the way, let us press straight to the mark. In place of proceeding empirically with bandaged eyes, let us walk in the light of the sun, from which we shall demand the means of producing vegetable food not only at less outlay but with less labour.

The result to which we are led is, as we have said, very unexpected. It is that the produce of a hectare of land, estimated at 10,000 or 12,000 kilos. of a crop, demands a quantity of *vis viva* equal to 8,000 horse-power days. But a horse-power is equal to five men. Consequently the *vis viva* which a hectare of land requires to yield its crop is equivalent to the day's work of 40,000 men, for ten hectares 400,000, for 100 hectares 4,000,000, and for 200 hectares 8,000,000.

When I said that my army outvied that of all the conquerors was I not right? Generalise these results and see to what you are led. If we fix the human population of the globe at 1,200,000,000 inhabitants, 33,000 hectares—that is to say, scarcely the half of a French department—require to yield their crop a concentration of force represented by a day's work of the entire human species.

But this is not all; the quantity of *vis viva* which the sun sends us in the course of a year corresponds to 2,000,000 horse-power days per hectare.

Consequently if we only utilise 8,000 we lose 1,992,000 per hectare. You thus arrive at this final and unlooked-for conclusion, that 150 hectares of land—scarcely the extent of a private park—after having utilised what is required for the production of their crop, still lose by radiation into the celestial space *vis viva* equivalent to a day's work of the entire human race!

But I feel, gentlemen, you hardly follow me. You do not realise these novel notions; and yet if we have defined the *vis viva* which the production of a crop demands; if we have next found, not less accurately, how much energy is lost unutilised, our intelligence perceives immediately as a problem presented to it the quest of means to recover in part these lost forces; and, turning to the practical sphere, why do we not seek to produce simultaneously two plants, or to obtain at the same time two harvests upon the same plot of ground? And this inquiry is not the only one to which we must be led.

If we ask you at present why it is admitted almost as an axiom that cultivation by delegation is nearly impossible, the answer will present itself to your mind spontaneously. It is very easy to deduce these conclusions. From the moment we realise that the production of a crop requires the equivalent of a day's work of 40,000 men, in the shape of natural forces, and that for the same surface there is required in the days' work of men or beasts of burden only the equivalent of fifteen horse-power days, it results that human labour is to that of nature as 1 : 500; but with this distinction, that human labour is merely a directive power which may render the work of nature useful or hurtful. It is like the effort of the pilot which conducts his ship either to port or to the bottom. The slightest deviation is ruinous! for 8,000 horse-power per hectare are working against you. I must insist on this.

The farm-labourer does not produce; he serves merely to direct the forces of nature. This is why he is so difficult to manage, and why he may become so dangerous an auxiliary. Hence we should seek to minimise as far as possible human intervention in favour of natural forces which oppose to us neither strikes, nor neglect of work, nor treachery, nor conflicting interests.

When he understands the laws which command the forces of nature man is a sovereign. It is by setting out from these novel ideas, from these ideas which light up agricultural progress in its essence, that I have been led to institute a method of cultivation in which the intervention of human labour is reduced to the minimum possible both for the production of manure and for the preparation of the soil, thus ensuring to the management greater certainty and liberty of action. You will now perceive why it is so difficult to manage a farm at a distance, and so easy in comparison to direct a workshop. In the factory there is a direct connection between the workman and the product which he furnishes. In the farm the connection is very remote. The labourer is restricted to preparing for the intervention of exterior forces. The slightest shortcoming on his part is multiplied by the immensity of these forces.

In the workshop, if a machine sustains an injury it is at once repaired. In agricultural work the case is different. The machines—that is, the plants—cannot be repaired. If you have not sown them at the right time their work is injured beyond recall; the forces of nature act against you. If the soil has not been well prepared it is invaded by weeds, which seize upon the manure, to the detriment of the crop. In harvesting it is necessary to mow the weeds along with the useful product—expense incurred without compensation. When sold the crop is contaminated with worthless products, which reduce its selling price. In other words, in agriculture a fault is irreparable. In manufactures it can be repaired. In farming the intervention of human labour is but an infinitesimal fraction with respect to the forces of nature, which alone are the source of the useful product.

If a malicious intention or a fraudulent interest creeps into the organisation of a farm, how can the proprietor hope to succeed when he has 8,000 horse-power per hectare always working against him?

All the great industrialists who take up cultivation and who wish to remain faithful to the procedures with which they are familiar almost invariably deceive themselves. If you tell them that to be ready in time there is needed a foresight always on the alert, they will answer, with a smile on their lips, that they have improved machines and money, without reflecting that in agriculture machines can neither work in all weathers nor surmount all obstacles, whilst the forces of Nature never make holiday.

The stratum of arable soil extended over the surface of a hectare amounts to 4,000,000 kilos.; for ten hectares 40,000,000 kilos.; and for a hundred hectares 400,000,000 kilos. Do you believe that you can handle such masses suddenly? No; in agriculture the procedures are the reverse of those in manufactures; in agriculture you must act slowly. You must not consider what can be begun, but what can be completed. Your effort must be concentrated upon a single point and applied slowly. The fecundity of the work springs from the unbroken succession of efforts, and not from their sudden and changing concentration. Rapid concentration means ruin. Concentration slowly and successively applied means success, as experience has recognised. But practice is often unable to explain the traditions to which it strives to remain faithful. In order to substitute true laws for the precepts which she follows we must analyse the agricultural problem to the very bottom, distinguishing the labour of the natural forces, which alone are productive, from the intervention of the human hand, which directs and commands them.

There remains a last question—that of capital. Let us remember that the agricultural problem is composed of three terms: the substance which forms the crop, the force which transforms such substance, and the capital which sets the two to work.

Here, then, appears a new contrast between agriculture and manufactures.

In agriculture we must not be weary of repeating that nine-tenths of the substance which forms the crop, has its origin in two natural sources, air and water, the atmosphere and the rain. The *vis viva* which makes the harvest comes almost entirely from the sun. The sun gives in reality five hundred parts, whilst man aided by animals scarcely yields one. As regards capital, the contrast is equally great.

In commerce and manufactures the first rule of success is to turn over capital as quickly as possible; it is to multiply the operations. In a well-managed industry the capital is turned over two or three times in the course of a year. In agriculture scarcely half the capital can be turned over in the same time.

A striking instance appears in the establishment of Petit Bourg, directed by M. Decauville, the promoter of narrow railways, who bids fair to take a position of the highest order in French industry, if he has not already secured it. Before becoming a manufacturer M. Decauville was a farmer. He managed a farm of 450 hectares, and, by his own admission, he incurred serious losses. Subsequently he created the industry of narrow railways, in which he has realised great profits. It is with his consent that I make of him a living example of the contrast between farming and manufactures, as far as capital is concerned. As an industrialist, he operates with a capital of about three million francs, represented by one million in materials, one million in stores, and one million of available funds. With these three millions he produced last year eight million francs' worth of railway lines and of rolling stock, and this year he calculates upon reaching twelve millions. Last year he turned over his capital three times, and this year he will turn it over four times. Each turn-over of capital represents a profit.

In the United States the principle of the multiplication of profits is carried still further. There are joint-stock spinning works representing a capital of eighty to one hundred million francs. In the course of a week cotton in pods enters at one gate and goes out at another in the state of cloth.

In the course of a week it is carded, spun, and woven. Simultaneously with this work there is accomplished one quite distinct. The seed is ground; there is expressed from it an acrid oil, which is rendered fit for consumption by a special treatment. Thus there issue from the works calico, oil, and oil-cake in exchange for the pods of the cotton-tree. As there are fifty-two weeks in the year, the works turn over their capital fifty-two times.

In farming the procedure is quite different. At Petit Bourg, with a capital of 600,000 francs, there is great difficulty in turning over 300,000 francs yearly from average crops. And the profit must come from this annual crop.

There is, then, a radical opposition between farming and manufactures. But, however disadvantageous the contrast seems for the agriculturist from a financial point of view, one condition redeems it. The raw material upon which the farmer operates is derived to the extent of nine-tenths from infinite, exhaustless natural sources which cost him nothing, while the forces which put this raw material in action cost also nothing. The sun bears almost the entire burden. The more I study, the more I scrutinise the agricultural problem, and the more I endeavour to eliminate my unpleasant personal experiences which others have been able to avoid, the more I am led to the conclusion that agriculture is the most fruitful of the industries, the one which ought to give the most remunerative results.

But you will reply that in farming success is rare, and that the most eminent agriculturists do not rapidly grow rich.

I admit it. But the professed farmer does not know the laws of Nature. He operates according to rule-of-thumb data, which materially reduces his profit, so that it is merely a disguised salary. For men of science the condition is quite different; they know better how to employ manures and forces, but for want of managing their labourers as well as the professed farmer can, coalitions and treachery make them almost entirely lose their advantages.

A workman who manages fifteen or twenty thousand horse-power, real, though not visible, is very strong to do evil.

Success can spring only from the association of practice and theory, and perhaps from the participation of the labourer in the profits.

I affirm—and the future will make good my assertion—that the day when agriculture possesses good bodies of workmen, it will be the most fruitful and remunerative of industries. And I add, it must be so if the Old World is to resist the competition of new communities. Gentlemen, we must exaggerate nothing, but we must have the courage to view the situation in all its gravity.

You have, on the one hand, rising communities where land costs scarcely anything, and where each year a million of emigrants, lost for the Old World, bring, with their intelligence and their arms, money sufficient to be used to advantage.

On the contrary the Old World has lost the flower of her children, and with each of them 5,000 to 6,000 francs of effective outlay; this for a million emigrants represents a clear loss of five to six milliards yearly, in the form of the most perfect instrument of production.

But this is not all. When scarcely landed, the first word of the emigrant is to say to his mother-country, 'I have come to compete with you!'

And what is the result of this competition? We cannot deny it at present. Wheat may be produced in the United States at ten or twelve francs per hectolitre, and in India at five or six francs. Now you know what wheat costs to produce in the Old World with land at 1,000, 2,000, and 3,000 francs per hectare, and labourers' wages at three to four francs daily; and especially you know the antagonism which exists between the rural and the urban classes, without speaking of the crushing burden of our military system. I do not cite figures, because I wish to avoid useless discussions. Hitherto it has been the custom to speak of a crisis, but, to speak the truth, there is no crisis. It is a new order of things which begins and which will not end; it is the competition of new communities more favoured than ourselves, and with whom the struggle will become permanent. True crises will be produced in seasons when the harvests will be abundant in America and in Europe. You will then know the extent of effort you will have to make to defend yourselves. But childish lamentations are no defence. To gain in the struggle you must seek out new solutions. You must demand from Science, guided by a will which nothing ought to weary, the secret of the application of all the elements, substantial and potential, which Nature has furnished us, and which she still holds in reserve to raise our means of production. What cause was ever grander and more beautiful? The cause of the earth is that of humanity. The earth feeds us, and when we reach the term of our existence she receives our bodies. The earth is the emblem of the treasure won by labour. She is the living affirmation of our country. To render fertile the workings of the earth is to give prosperity to the present, security to the future, and a scope and recompense to human labour in the most fruitful region.

SECOND LECTURE

THE USE OF MANURES

Gentlemen, our lecture to-day will have a character absolutely different from the former one. Like a traveller who has to explore a vast extent of country I caused you to climb a lofty ridge, so as better to take in the horizon. To-day the object is quite different. It must be practical. From the regions of theory we must descend to the reality of facts and of effective and fruitful applications. In consequence to-day's lecture will be a deduction from the foregoing.

In the former lecture we had science and theory; to-day it is science and practice.

Among the results at which we arrived I will remind you that with one part of manure we obtain ten parts of crop; therefore nine-tenths of the crop are derived from natural sources which cost us nothing. But the quantity of manure given to the soil has no efficacy save under one condition—that is, that a source of *vis viva* pervades the plant and enables it to absorb and assimilate the elements which it has drawn from the soil and the air. Here the *vis viva* is the sun, and I must remind you that to obtain a yearly return of 10,000 to 12,000 kilos. per hectare the plant must receive in the form of light and heat the equivalent of 8,000 horse-power days.

Here is a grave and a dangerous circumstance. If a fault has been once committed, forces whose action you cannot suspend prevent you from rectifying it. You are obliged to go on to the end. But everything being duly weighed, duly considered, agriculture remains the foremost of the industries; and if success is so rare, especially under present conditions, it is because to arrive at success there is required a combination of science, of intelligence, of order, and of control over the persons employed which industry does not demand. From the moment when a human effort expressed by 1 solicits and provokes a parallel effort equal to 500, due to natural forces, the slightest shortcoming makes these 500 work against you. Consequently we must give to the farm a constitution quite different from that of the workshop. But when the mind in its independence and its recollection revises the operations; when it places itself above accidents, when it rises so as to have the power of vanquishing all obstacles to the notion of truth in its absolute expression, it arrives at this conclusion, that agriculture is the foremost of all industries.

Gentlemen, we must pass from this purely theoretical affirmation into the domain of facts. It is by experience, by the testimony not of reason, but of facts which overpower us, of facts which we can touch, of facts which we may feel, and which often dominate us, that I am about to attempt my demonstration.

I told you that in all plants indifferently there are fourteen elements; whether they are poisonous, nutritious, odoriferous, &c., they always contain fourteen elements. But I added that among these fourteen elements there are three—carbon, hydrogen, and oxygen—which enter into the composition of plants to the extent of 94 per cent.; that the carbon has its origin in the carbonic acid of the air; that the hydrogen and the oxygen have their source in the water which permeates the soil; but that we must give to the plants, and to the soil at the same time, nitrogenous matter and the mineral elements which you find in the table to the number of ten;

and that on condition of giving these ten minerals and the nitrogenous matter you satisfy all the demands of plant life.

But if this is true it follows that we can produce plants artificially and at will. Let us try this creation, let us take a porcelain pot and fill it with sand ignited in a porcelain furnace. This sand is snow-white, it contains nothing soluble. We moisten it with distilled water and sow in it twenty grains of corn. In this pot thus prepared, without any addition, the twenty grains of corn, the average weight of which is one gramme, will yield six grammes of a crop. Analyse the seed, analyse the crop, and you will find that the five grammes of surplus consist of carbon, hydrogen, and oxygen. They contain absolutely nothing more. The substance of the seed has added to itself these five grammes. Hence it is quite true that a seed sown in an inert soil draws from the ambient sources, that is from the air and the water which pervade the soil, the surplus substance of its tissues, a surplus which in this particular case is expressed by five grammes.

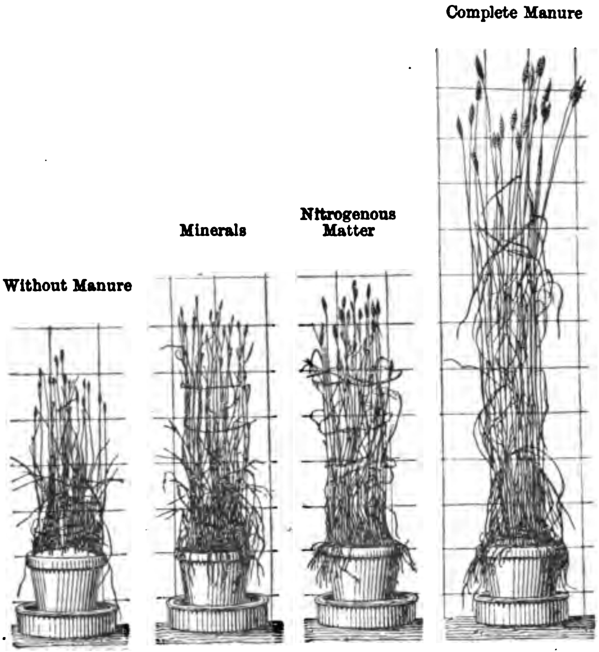
The assertion that water and air contribute to the nutrition of plants is thus established. But let us now add to this ignited sand the mineral elements phosphate, potash, lime, &c.; in short, the ten mineral elements; let us moisten with distilled water and again sow twenty grains of wheat, weighing one gramme as before. We shall now obtain a crop of eight grammes. Before we had only six; now we have eight.

Let us add, in the third place, nitrogenous matter alone (without the minerals). We have now a crop of nine grammes instead of eight.

In all these circumstances the vegetation is precarious. But it furnishes us with a precious lesson by demonstrating that a plant may be made to live in calcined sand. Certainly this corn is in no respect comparable to our crops. It scarcely reaches the height of 20 to 25 centimetres. The stalk has barely the diameter of a knitting-needle, and the ear yields merely a rudiment of grains. This is not vegetation, it is simply the affirmation that the plant is alive.

We have now to make a final experiment—to join the nitrogenous matter to the mineral elements; adding to the sand at the same time the nitrogenous matter which had yielded nine grammes and the mineral elements which produced eight. This time the result is superb. The sand which had been heated for a week to incandescence in a porcelain furnace, which was like snow in whiteness, and in which we have been able to produce only a feeble manifestation of vegetable life, becomes equal in fertility to the best soils. You see wheat flourishing as luxuriantly as you could wish, reaching the

CULTIVATION IN CALCINED SAND



Yield for Twenty Grains of Seed

	Grammes	Grammes	Grammes	Grammes
Straw	5·42	6·32	9·16	16·48
Grain	0·07	0·54	0·09	4·30
	5·49	6·86	9·25	20·78

height of 1½ metre and yielding excellent grain, which, if sown, germinates in its turn, vegetates, and fructifies. In this calcined sand you have realised vegetation in its highest power. Vegetation is, therefore, conquered and defined in its most essential conditions.

When I said in my last lecture that we might dispense with giving to the soil carbon, hydrogen, or oxygen, I merely anticipated the results of this experiment. This is not theory; it is not abstract science; it is a practical experiment of the simplest and the most conclusive nature. A pot of sand, which of itself produces nothing, yields you a crop of ten for one if you add minerals and nitrogenous matter. I repeat vegetation is thus conquered for ever. These results being thus obtained, the consequences may be carried further. Since the intervention of nitrogenous matter is necessary if the minerals are to exert their influence on vegetation, you can conceive a series of new experiments in which the nitrogenous matter being maintained as a constant term, there are associated with it the ten minerals which you know; then other experiments in which the number of the minerals is reduced to nine, that is to say, in which a different mineral is omitted each time. The injury which vegetation receives from these successive suppressions shows the special importance of the rôle of each mineral. For instance, you suppress the phosphate; the plant dies; no vegetation. You omit the potassa; the plant droops; the stem has no rigidity. You replace the potassa with soda; this is not possible; soda is useless to vegetation. You suppress the magnesia; the vegetation is poor. In place of a crop of twenty or thirty grammes, you have only six. By such successive suppressions you succeed in determining the influence of each of the minerals, and consequently in defining all the substantial influences which may intervene in the life of a plant. You realise this marvel, that a soil containing nothing, where vegetation is reduced to the most precarious grade, passes without transition by the addition of some chemical products to the highest degree of fertility.

Here is no hypothesis, no theory. If we consider these experiments we feel animated with a faith which fears nothing, because the vegetation has sprung up underneath our hands. What we have said vegetation affirms, and to-day these results are confirmed by the farmers of all countries. It is absolute truth. It remains for us to deduce from it other practical consequences.

To sum up. I commenced with sand, which is merely a mechanical support for the cultivation of the seeds without any addition. I obtained six parts of produce. I added to this sand the minerals which the incineration of plants grown in a fruitful soil leaves behind. This addition gave an increase of two, that is, a crop of eight parts in place of six. The addition of nitrogenous matter without minerals gave nine parts, i.e. more than the ten minerals collectively. The nitrogenous matter associated with the ten minerals raised vegetation to its highest degree of power.

Lastly calcined sand receives as a constant term the nitrogenous matter and nine minerals in place of ten, and the experiments are multiplied such a number of times that each mineral may be omitted in turn, which permits us to isolate the function of each and to state with certainty in the totality of the results obtained the rôle which belongs to each one in particular.

Let us now suppose a new series of experiments; our starting-point will still be calcined sand which has received at once the nitrogenous matter and the ten minerals, the dose of the former being invariable. But instead of suppressing we increase this time the dose of the minerals; we increase the dose of phosphate. It produces no result. You increase the potassa; no result. You increase the proportion of all the minerals combined; there is still no result. You had previously a crop of twenty-two grammes and you still have no more. But, inverting the process, I suppose that you make a new trial in which the constant term is not the nitrogenous matter but the ten minerals, and that you add to the ignited sand nitrogenous matter in constantly increasing proportions. The result is unexpected; the yield changes at once and becomes corresponding to the quantity of nitrogenous matter employed. The experiment, therefore, leads us to the novel conclusion that nitrogenous matter exerts a function superior to that of the ten minerals. If alone it is almost insignificant; if associated with the ten minerals it is all-powerful, with this novel conclusion, that the dose of the nitrogenous matter determines the quantity of the crop, whilst the increase of the mineral elements is without influence.

There is therefore an action in two degrees: in one degree with the minerals, in the second with nitrogenous matter. To translate this idea I call the element which determines the yield of the crop of a plant the *dominant* of that plant.

For wheat the *dominant* is nitrogenous matter.

Either I am mistaken, or these results carry with them an irresistible degree of evidence. The demonstration required to be furnished is not of a complicated and difficult character. It is, on the contrary, very simple, since there are required a few porcelain flower-pots, a little calcined sand, and some salts, to obtain, not merely luxuriant vegetation, but to determine the function of each of the substances employed, and to show plainly the functional contrast which exists between the minerals and the nitrogenous matter.

How, you will ask me, can practical husbandry draw advantage from these results; how can they be applied?

Let us substitute for the calcined sand a natural soil, and we discover at once that to obtain the maximum of fertility it is not necessary to add to the earth all the ten minerals, but only three: lime, calcium phosphate, and potassa. It is useless to give magnesia, silica, oxide of iron, soda, chlorine. Why should that which is so useful in the sand be useless in natural soils? For the very simple reason that natural soils are provided with an excess of all these elements. Consequently when we wish to pass from vegetable life in an artificial and inert medium to vegetable life in a natural soil it is permissible to omit the minerals which are found to be superfluous.

I say superfluous, not because they do not exert a useful and even an essential function, but because the soil already contains them. If you add more there is no result. It happens as we have already said concerning carbon, the addition of which to the soil is not followed by any effect, because the plants obtain it from the carbonic acid of the air. Consequently when you pass from ignited sand to a natural soil, or wish to fertilise such soil by means of chemical manures, you find that nitrogenous matter and three minerals are sufficient, whilst if you operate on ignited sand you need a nitrogenous matter and ten minerals.

When reduced to these terms the problem assumes an extreme simplicity. For whereas in ignited sand—that is to say, in an absolutely barren medium—it is necessary to use nitrogenous matter and ten minerals, in practice nitrogenous matter, potassa, phosphate, and lime suffice. The combination of these four bodies realises the conditions of the most luxuriant vegetation, and we call it the *complete manure*. Just as a waggon loaded with coal conveys power, in like manner a waggon loaded with these four substances conveys fertility in a latent state.

These contingent conditions of fertility you can realise if you derive these substances from natural sources, where they exist as minerals; deposits unknown in the past, which a beneficent Providence seems to have kept in reserve to enable us to increase the productive power of the soil in proportion as the population increases, and which lie outside the procedures used in the past, when it was necessary to produce at once the manure and the crop. As for manure, we can produce it completely; we can vary its composition, graduating its effects; and by its means we can regulate vegetable activity, just as a stoker regulates his engine. A little more of this element, a little less of that, and you produce with equal ease wheat, or forage, sugar in beet-root, or oil in colza.

The problem of vegetation is solved. Experience verifies what I am saying, and it is the honour of our times to have formulated the propositions in which these conquests are summarised.

I promised to be practical, and I will not break my word. We will proceed to practice and note a result of the highest importance.

Let us repeat the recent experiments, not in calcined sand, but in good soil, with the aid of what we call the *complete manure*. That is the association of these four items: potassa, phosphate, lime, and nitrogen. We experiment upon wheat, and we successively increase the dose of phosphate, of potassa, and of lime, still keeping the nitrogenous matter as a constant quantity. The result is completely null. On the contrary, if we keep the dose of phosphate, of potassa, and of lime as a constant quantity, and increase that of nitrogenous matter, the increase of the crop follows a corresponding progression. It is the repetition in good soil of that which has taken place in sand.

Let us make the same experiment upon the vine. We increase the dose of nitrogenous matter; the result is unimportant. We increase that of potassa; the crop is augmented accordingly. We suppress the potash entirely, and we do not obtain a single grape. For ten years I have experimented upon plots of vines, separated by a road of a metre in width. Here we obtain 10,000 to 12,000 kilos. of grapes—that is, 100 hectolitres of wine. On the opposite side nothing—inanition, stunted vines, and not a single grape.

As to the difference between the two plots, there is none in their origin; there is no difference in the vines. The only difference existing is that between the soil of the two plots: the one has been exhausted of potassa and the other has not been; to one of the plots there has been given nitrogen, phosphate, lime, and potassa. The other plot has received nitrogen, phosphate, lime, and *no potassa.*

Third and last experiment. You give potassa in varying doses. In proportion as the dose of potassa is augmented the quantity of the crop of grapes increases. What I say of the vine holds good as regards leguminous plants, peas, and beans. The nitrogenous matter does not exert the preponderating function which it does for wheat. This function passes to potassa. Extend the same system of experimentation to the potato. Here potassa is still the determining element, not nitrogenous matter.

From the potato, the vine, the pea, and the bean we pass to sugar-cane, sorgho, and maize. Here the crop is regulated neither by nitrogenous matter nor by potassa, but by calcium phosphate. Thus the facts prove our second proposition in all its admirable simplicity and fecundity; that is to say, among the four constituents of the complete manure there are three—phosphate, potassa, and nitrogenous matter—each of which, according to the nature of plants, may play either a subordinate or a preponderating part. Nitrogenous matter preponderates for beets, colza, and wheat. We call it the *dominant* of these plants. For the legumina, the vine, clover, lucern, and potato, potassa preponderates, whilst nitrogen falls into the second rank. We find, lastly, that phosphate is the dominant of the sugar-cane, of sorgho, and maize. As for lime, necessary for all plants, it is not the dominant of any.

What simpler proposition can you demand? Do you wish for the unanswerable demonstration of this second proposition? Cast your eyes on this table.

Let us begin with the plants whose dominant is nitrogenous matter.

—	Yield per hectare	
	Wheat	Colza
	Hectol.	Hectol.
Complete manure	39	39
— — without lime	37	27
— — — potassa	28	20
— — — phosphate	24	16
— — — *nitrogen*	13	15
Without any manure	11	2

Upon beets the effect of nitrogen is not less striking.

	Kilos.		Kilos.
Complete manure	50,000	with 80 kil. nitrogen	47,000
— — without lime	47,000	„ 100 „ „	51,000
— — — potassa	42,000	„ 120 „ „	59,000
— — — phosphate	37,000		
— — — *nitrogen*	36,000		
Without any manure	23,000		

The omission of nitrogen gives the severest blow. Let us pass to the potato and the vine. Here potassa is dominant.

—	Potato, 1863	Vine, 1875	
		Grapes	Juice
	Kilos.		Hect.
Complete manure	27,950	12,000	96
— — without lime	23,350	7,000	62
— — — phosphate	17,900	7,300	58
— — — nitrogen	16,750	6,200	50
— — — *potassa*	10,520	—	—
Without any manure	7,700	—	—

Upon sugar-cane the effects are not less striking with phosphate as the preponderating element.

	Sugar-cane
Complete manure	57,600
— — without lime	50,000
— — — potassa	35,000
— — — *phosphate*	15,000
— — — nitrogenous matter	56,000
Without any manure	3,000

The better to emphasise the importance and the fecundity of the law of dominants, I reproduce the last series parallel to the series of beet.

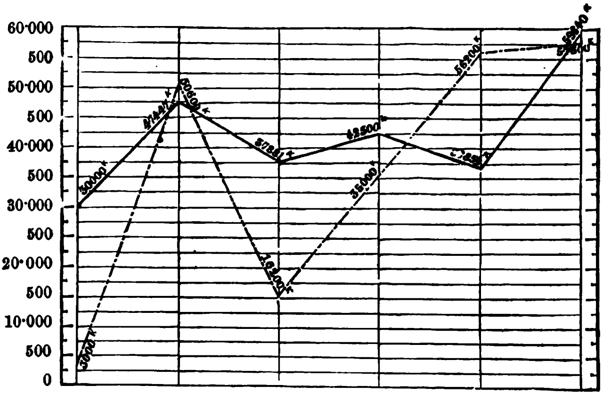
The sugar-cane and the beet are both plants yielding sugar, but the dominant of the cane is phosphate, and that of the beet is nitrogenous matter. Compare these two remarkable series term by term, and draw the conclusion yourselves.

	Yield per hectare	
	Sugar-cane	Beet
	Kilos.	Kilos.
Complete manure	57,000	51,000
— — without lime	50,000	47,000
— — — potassa	35,000	42,000
— — — *phosphate*	15,000	37,000
— — — *nitrogenous matter*	56,000	36,000
Without any manure	3,000	25,000

The contrast is here so strikingly affirmative that I do not hesitate to reproduce it once more in the form of a graphic tracing, more striking to many minds than the contrast of figures.

Such are the effects of dominants; and on this point I must add that this function is not absolute. It varies with the nature of the plants, so that the substance which is the dominant in one case is in another merely a subordinate element. Here is the result of vegetation in the experimental field at Vincennes—that is to say, in a soil as exhausted as could be wished for obtaining absolute demonstrations.

Comparison of Sugar-cane and Beet-root

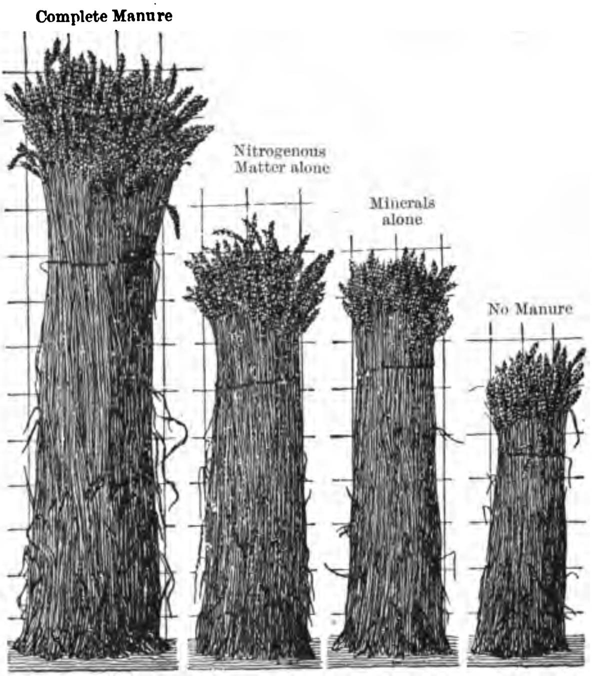


Explanation: Beet-root———— Sugar-cane —·—·—·—

This confirmation of the facts by nature will be our last word on the law of dominants.

We have thus demonstrated without appeal the truth of this new and important proposition, that among the four constituents of a manure there is one which exerts a preponderating, regulative function—a practical result if ever there was one.

Experimental Field at Vincennes. Harvest of 1863.



Yield per Hectare.

	Kilos.	Kilos.	Kilos.	Kilos.
Straw	6,941	3,487	3,003	2,640
Grain	3,750	1,620	1,287	902
	Hect.	Hect.	Hect.	Hect.
Grain	46	20	16	11

Hence flows the novel conclusion that manure does not represent, from a substantial point of view, atom for atom, all that the plant contains. The manure is merely a supplementary item; it is the complement of what is given by the air and the rain in a tenfold larger quantity without any expense; but, accordingly as you know or do not know the dominant, you obtain at an almost equal expense a crop ten times larger or ten times smaller. The knowledge of the dominant is in reality *the* condition of profit. Give nitrogenous matter to peas: the result is null. Give nitrogenous matter to lucern and sugar-cane: the result is nearly null. But give the sugar-cane phosphate; give peas potassa; give wheat nitrogenous matter; give each plant its dominant, and you will be rewarded for your trouble by a remunerative crop. The plants will respond to your expectations with an implicit submission. They cannot withdraw themselves from these true laws—positive laws which agricultural practice has verified in all countries, and which the Old World has certainly the right to claim and to utilise to defend itself against the menaces of the New World.

Here then occurs a question. You are about to ask me: But these new agents, the efficacy of which cannot be doubted, by what rules ought they to be associated?

You will perhaps say to me, You have just explained general results: we need indications more positive and more special.

Very well, gentlemen, it is easy to satisfy you, and in a few words I am about to put you in possession of the rules which must be followed in compounding manures.

Plants, as we have seen, are divided, as concerns their dominants, into three classes—those with a dominant of nitrogen, those with a dominant of potassa, and those with a dominant of calcium phosphate. It is a remarkable fact that, whilst botanists group plants according to structural resemblance, the conditions which vegetable life demands are often in opposition to these distinctions. Thus, although the beet and the turnip are two very similar plants, both cultivated for the sake of their roots, yet their dominants are different; beet-root must be treated like wheat, and the turnip like the sugar-cane.

We return to manures. To answer all the demands of farming, I have admitted five principal classes—

Complete manures.
Homologous manures.
Intense manures.

Incomplete manures.
Manures for special purposes.

1. *Complete Manures.*—They contain the four tems which you know—nitrogenous matter, calcium phosphate, potassa, and lime; always these four terms, but in different proportions.

For the plants which have potassa as their dominant you use less nitrogen and less phosphate, but more potassa. For those with a dominant of nitrogen you use less potassa, less phosphate, but more nitrogenous matter. For plants with a phosphatic dominant you give less potassa and less nitrogen, but more phosphate.

In place of giving an inflexible formula for manures, we vary the dose of the four constituents according to the requirements of the plants.

2. *Homologous Manures*, 1′.—These possess the same composition as the complete manures, but the potassa and the phosphate appear in a different form. In the complete manure No. 1, for instance, potassa is employed in the state of potassium nitrate, in which there are forty-eight per cent. of potassa to fourteen of nitrogen. The homologous manure No. 1′ is equally rich with the complete manure No. 1, but it differs in so far as for the

potassium nitrate there is substituted a mixture of potassium chloride and ammonium sulphate, so as to contain also forty-eight parts of potassa and fourteen of nitrogen.

It is very important to know the degree of utility of one and the same body in different forms, so that recourse may be had to the one or the other, according to the prices. From five to six years ago the price of potassium nitrate was always rising, on account of the demands made by agriculture; but since it has been proved that for potash-saltpetre we may substitute a mixture of potassium chloride and ammonium sulphate, so as to realise the same richness in potassa and in nitrogen, the rise in nitrate ceased at once.

For colza, for corn, and for grass-land the homologous manure is worth as much as the ordinary complete manure, or even more; but for potatoes it is of less value.

Thanks to this homologous manure, we have been able to counteract the rise in potash saltpetre, and multiply its applications whilst effecting the greatest possible economy.

I repeat, the homologous manures differ from the complete manures by the state of the potassa which is present in the complete manure in the form of nitrate, whilst in the homologous manures it is present in the mixture of potassium chloride and ammonium sulphate. The manures of this class bear the same number as the corresponding complete manures, only there is placed at the right hand of the number the mark ′.

Homologous Manures, 1p.—We come to the second class of homologous manures, p. In these manures the phosphate, instead of being employed in the state of superphosphate, figures in the state of precipitated phosphate, PO_5, 2CaO, HO + aq.[1]

3. *Intense Manures.*—After the complete manures and the homologous manures come the *intense* manures. These are manures in which the dominant figures in a dose higher than that which occurs in the simple complete manures.

4. *Incomplete Manures.*—After the intense manures follow the *incomplete* manures. These are manures in which we suppress in turn either the phosphate or the potassa, or the nitrogenous matter, because there are soils superabundantly provided with these elements, and which consequently do not need to be supplied with them.

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[1] In the appendix will be found the history of each substance which enters into the composition of manures.

We have, therefore, the following series of manures :—

The *complete manures*, which satisfy all the conditions of vegetable life.

The homologous manures, which reproduce the constitution of the complete manures, but with this distinction, that the potassa or the phosphate appears here in a different form.

The *intense manures*, which are complete manures with an excess of the dominant.

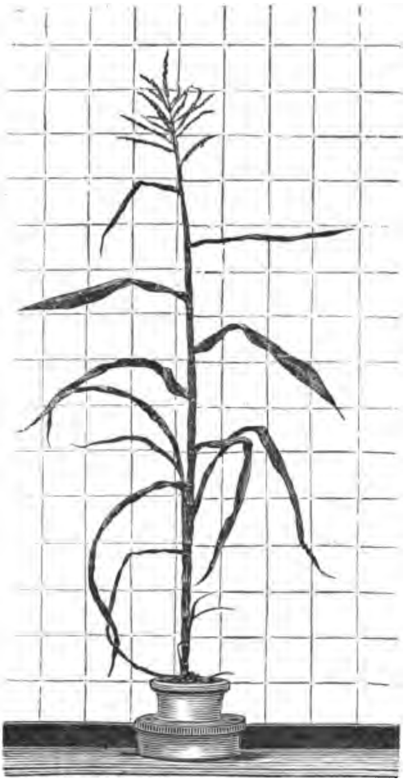
The *incomplete manures*, where one of the four terms is suppressed according as it is naturally present in the soil.

5. *Special Manures.*—There is, finally, a last class of manures, on which I will say only a word; but this word is the affirmation of an advance which you will have some difficulty in believing. Here are the photographs of two pots in which maize has been cultivated. In each case a manure equally rich has been given. In one case the maize sends up a stem much higher than in the other; it is covered with leaves, but it is completely devoid of ears and consequently of grain.

In the second pot the stem is lower, but it bears a fine ear loaded with grain.

What is the difference between the two manures?

In the one the potassa is supplied as potassium sulphate; in the other it is present as potassium chloride. What are we to conclude? It is that we cannot merely graduate the quantity of the crop,



MAIZE: ABUNDANT STEM, NO GRAIN (see p. 58) but that we can produce an effect more profound by determining at will the preferential formation of such or such a part of the plant. If we wish for grain, we aim at the production of ears; we wish for forage and we aim at the production of leaves; we want grapes and we aim at the production of fruit. Here vegetation is not merely at our command in its entirety; it is regulated as to the nature

Maize: Moderate Stem, Abundant Grain (see p. 58) or the quality of the product which we wish to obtain. It is a further advance on our first results, it is a further step in the integration of the elements which concur in the synthesis of the vegetable organism.

To show, finally, by an example how the five classes of manures are mutually connected let us consider the total series derived from their common generator, the complete manure No. 1.

	—	Per ct.	Per hect.
			Kilos.
Complete Manure, No. 1.	Superphosphate	33·34	400
	Potash-saltpetre	16·66	200
	Ammonium sulphate	20·83	250
	Gypsum	29·17	350
Homologous Manure, No. 1′.	Superphosphate	33·34	400
	Potassium chloride (80 per cent.)	16·66	200
	Ammonium sulphate	32·50	390
	Gypsum	17·50	210
Homologous Manure, No. 1p	Precipitated phosphate	17·00	170
	Potash-saltpetre	20·00	200
	Ammonium sulphate	25·00	250
	Gypsum	38·00	380
Intense Manure, No. 1.	Superphosphate	30·76	400
	Potash-saltpetre	15·40	200
	Ammonium sulphate	26·92	350
	Gypsum	26·92	350
Incomplete Manure, No. 1. No potash.	Superphosphate	40·00	400
	Ammonium sulphate	35·00	350
	Gypsum	25·00	250
Incomplete Manure, No. 6. No nitrogen.	Superphosphate	40·00	400
	Potassium chloride (80 per cent.)	20·00	200
	Gypsum	40·00	400

Hitherto I have spoken of vegetation and of manures in an absolute sense. I have given you the composition of the manures suitable for different plants. This composition is shown in the tables, but in practice we do not proceed in this manner. In practice we adopt what is called a rotation—a successive order of crops.

How, therefore, are we to employ the manures? I have just laid before you the solution of the simplest case, the exclusive cultivation of one and the same plant, and I have shown you that the composition of the manure is deduced from the requirements of each plant with reference to the *dominant*. But to tell the truth this case is exceptional, and to be complete and practical we must show the succession of the manures which it is proper to employ when we pursue a given rotation, which moreover is an easy matter. Let us take as the first instance a rotation which begins with potatoes, followed by spring-corn. The third year the land is occupied with clover, and the fourth with wheat. What must we do under these conditions? The first year we give the plant the complete manure No. 3 with a dominant of potash, and we obtain fine potatoes. The second year we give the soil merely the dominant of spring-corn, knowing that the manure has left in it such a stock of minerals that the dominant alone will secure a fine crop of wheat. The third year we apply the incomplete manure No. 6 which clover requires. The fourth year, for wheat, we give merely a moderate dose of nitrogenous matter.

We adapt to the rotation of crops a rotation of manures, taking care always to supply each crop with its dominant. We thus secure the maximum returns for the minimum outlay.

Two Years' Rotation, comprising Maize and Wheat.

—	Per hectare		
	Quantity	Price	Cost
First Year.—Maize.			
	Kilos.	Fr.	Fr.
Complete manure, No. 5, say	1,200	—	—
Superphosphate	600	72	190
Potash saltpetre	200	110	
Gypsum	400	8	
Second Year.—Wheat.			
Ammonium sulphate	300	105	105
Total outlay			295
Yearly outlay			147.50

ROTATION OF FIVE YEARS, COMPRISING POTATOES, WHEAT, CLOVER, COLZA, WHEAT.

—	Per hectare		
	Quantity	Price	Cost
First Year.—Potatoes.			
	Kilos.	Fr.	Fr.
Complete manure, No. 3, say	1,000	—	—
Superphosphate	400	48	219
Potash saltpetre	300	165	
Gypsum	300	6	
Second Year.—Wheat.			
Ammonium sulphate	300	105	105
Third Year.—Clover.			
Incomplete manure, No. 6, say	1,000	—	—
Superphosphate	400	48	92
Potassium chloride	200	36	
Gypsum	400	8	
Fourth Year.—Colzá.			
Ammonium sulphate	400	140	140
Fifth Year.—Wheat.			
Ammonium sulphate	300	105	105
Ash of straw and husks of colza	—	—	
Total outlay			661
Yearly outlay			132

There comes up now a further question: How is chemical manure to be connected with dung? What have I not been made to say concerning dung! What anathemas am I not accused of having fulminated against it! Here is my reply: Dung, old-fashioned dung, the ultimate term of the agricultural experience of the past, what is it in reality? Chemical manure of poor quality.

Here is the proof of this assertion:—

How Chemical Manures compare with Dung.

	100 parts of dung contain		
Water		80·00	Here are 80 per cent. of matter useless to vegetation.
Woody fibre	Carbon	6·80	13·29 per cent. of matter which is obtained from the air and the rain.
	Hydrogen	0·82	
	Oxygen	5·67	
Secondary minerals	Silica	4·32	5·07 per cent. with which the soil is superabundantly supplied, and which do not need to be given.
	Chlorine	0·04	
	Sulphuric acid	0·13	
	Iron oxide	0·34	
	Soda	—	
	Magnesia	0·24	
Active portion	Nitrogen	0·41	1·64 of chemical manure of which the soil does not contain sufficient, and which requires to be added.
	Phosphoric acid	0·18	
	Potassa	0·49	
	Lime	0·56	
		100·00	

In a hundred kilos. of dung there are first eighty kilos. of water. It is very evident that dung is not useful in virtue of the water which it contains. Animal liquids are not useful on account of their water, but of the soluble products of which the water is the vehicle. In carting a hundred tons of dung you carry eighty tons of moisture at a pure loss. Along with the water you find in dung 13·29 per cent. represented by carbon, hydrogen, and oxygen. These substances you obtain from the air and the rain. Next come the so-called secondary minerals with which every soil is supersaturated and which form 5·20 per cent. of dung.

There remain at last less than 2 per cent. represented by phosphoric acid, potash, lime, and nitrogen, the active part of the dung, and which is in reality a chemical manure. The dung is like Peruvian bark, whilst chemical manure is the quinine. Or we might say dung is like an ore, whilst chemical manure is the metal. Dung contains the active parts of the chemical manure. It is to these parts that its efficacy is due and to nothing else. If you have dung use it, but with discernment. That is to say, modify its composition according to the requirements of the plants: if you wish to produce a crop having potassa as its dominant add potassa as a complement to the dung; if you have a crop with a dominant of phosphate add phosphate; if your plants have nitrogen as their dominant add nitrogenous matter. You return thus to the general data of the doctrine of chemical manures by completing the composition of the dung in such a manner as to adapt it to the special requirements of each plant.

There is therefore no opposition between the teachings of the past and of the present: all these results enter under the same formula. How would you that dung should differ from chemical manure? Whence is dung obtained? From plants modified by animal digestion. The dung can only contain what the plant contained. By means of chemical manures we have scientifically produced plants which were similar to those obtained with dung. From the identity of results you are forced to admit an identity of causes. Dung owes its activity not to the water and the woody fibre which it contains, but to the phosphate, the potassa, the lime, and the nitrogenous matter which it contains. It is a chemical manure with an excess of gangue, which renders it more cumbrous, that is all.

Finally there comes up another question. I have just correlated chemical manure to dung. I must now correlate it to the soil. I wish to deduce from the composition of the earth at once the formula of the absolute manure for the ignited sand and the formula of the practical manure for natural soils.

How shall we represent vegetable soil?

In the grand generality of cases it is a mixture of clay, sand, and calcium carbonate. These three elements form the support of the plant without participating in its life. Along with these three substances, which we call the mechanical elements of the soil, we find invariably in all soils quantities of nitrogenous matter and ten minerals, the same which have served us for the production of plants in calcined sand. This mixture we call the absolute manure. But among the items of which it is composed there are seven of a mineral nature with which the soils are saturated, and by their omission we arrive at the practical manure.

How the Composition of Arable Mould is Related to the Theoretical Manure, and this again to the Practical Manure.

		Theoretical manure	Practical manure
Active assimilable elements of the soil	Organic	Ammoniacal salts Nitrates	Nitrogenous matter
	Minerals	Potassa	Potassa
		Soda	
		Lime	Lime
		Magnesia	
		Iron oxide	
		Manganese oxide	
		Chlorine	
		Sulphuric acid	
		Phosphoric acid	Phosphoric acid
		Silica	

I repeat, the omission of the seven secondary minerals leads to this new simplified formula: lime, potassa, phosphoric acid, and nitrogenous matter. This is the practical manure, connected with the composition of dung and deducible from the composition of the soil. It is suitable for all practical applications and carries with it the indelible stamp of truth because it is the direct affirmation of experience, positive and synthetic, in which there was no unknown condition.

There is no theory here. Experience speaks—experience definite in all its terms. From the practical results we pass to the phenomena, and from the phenomena we rise to causes; we acquire the notion of the just and the true. The mind rises to higher spheres, where reign order and eternal laws, for everything obeys law, and before the majesty of this result we feel that we also ought to formulate for ourselves laws, but laws to which we shall remain faithful; an inestimable result, for when we frame laws and obey them we realise liberty, the most sacred possession in the world.

THIRD LECTURE

THE MANAGEMENT OF FORCES AND THEIR RESULT

Gentlemen, we have arrived at the culminating point of our researches. It remains for us to specify the cause of success and of failure in agricultural industry. The present lecture will be the complement of the two former, and will justify the principles which I have explained and defended.

One thing in the question which occupies us is very striking: how rare are those agriculturists who raise their condition beyond the rural class. I do not know one.

I am about to mention three examples followed by ill success, examples before which pretensions ought to bow.

At the end of the last century Lavoisier, the founder of modern chemistry, who was also a *fermier général*, and moreover an administrator and financier of the highest rank, according to the admission of his contemporaries, was led by the course of his studies to wish to understand thoroughly the agricultural question. In order to define with accuracy all the interests therewith connected he purchased a farm of eighty hectares, situated between Blois and Vendôme; and to give more generality to his investigations he farmed besides a tithe which enabled him to be interested in almost all the manufactures of the country. But after eight years of studies and expenses Lavoisier, the great Lavoisier, tells us that 'the agricultural question is more difficult than I thought. Despite all my endeavours, I have not been able to recover the interest on my capital; and what distresses me most is not my personal mistake, but the proof acquired at my expense that the labourer who cultivates the land in the sweat of his brow does not come off better than myself.'

Let it be well understood, it is Lavoisier who speaks!

The second attempt is due to a man whom we cannot admit in the same rank as Lavoisier, but whom public gratitude has still placed very high. I speak of Mathieu de Dombasle, the founder of the Institute of Roville. Mathieu de Dombasle was a former pupil of the Ecole Polytechnique. At the epoch when the beet-sugar industry made its appearance he became its champion, though without success. At this time the cultivation of clover on a large scale was undertaken, and Mathieu de Dombasle, struck with the results which this crop had yielded, thought that with a small capital, by dint of combinations of rotation, he might improve the soil and raise the standard of production, so as to obtain considerable profits. To give his demonstration a higher character of utility he became a simple farmer. He borrowed a small capital and he laboured for eight years at Roville, in the modest establishment which public esteem has since decorated with the title the Institute of Roville.

Mathieu de Dombasle brought to bear everything with which foresight, wisdom, and the most attentive economy could inspire a loyal mind animated with the spirit of an apostle, to arrive at what? To a failure so signal that it forced him to abandon his task!

This is very serious, but the assertion is not mine. I have received from Mathieu de Dombasle himself the balance-sheet which sums up the losses which he sustained during these eight years:—

RESULTS OF FARMING AT ROVILLE FROM 1824 TO 1832.

Year	Profit	Loss
	Francs	Francs
1824	—	11,732.67
1825	5,771.74	—
1826	—	1,944.23
1827	—	920.35
1828	—	7,097.26
1829	7,384.14	—
1830	874.71	—
1831	—	11,866.90
1832	—	9,298.79
	14,030.59	42,860.20
Total loss . . 28,829.61 francs.		

28,829.61 francs loss! Mathieu Dombasle, therefore, did not succeed! Yet he prepared his land as it had never been prepared previously. He was, in fact, the promoter of improved agricultural machinery; but, as a further mockery of fate, during his life-time not one of his neighbours would employ his plough. After his death everyone adopted it, and this humble manufactory has become one of the most prosperous of France. Everyone now recognises the superiority of the instruments which it despised in the life-time of Mathieu de Dombasle, and which no one then was willing to use.

When I encounter this name on my way I

always bow to it with respect. The science of his day did not enable him to do better. But with the candour of a brave man he has given us his accounts. He has admitted his failure, and it is with the data he furnishes us that I am about to let you know the real cause of his defeat.

It is a memorial of successes and reverses in agricultural undertakings, the result of his personal experience—it is, in fact, a moral treatise on the qualities and defects of men. I will rise higher.

The problem of agricultural production is in the first place and above all things a natural phenomenon. As a natural phenomenon I analyse it; as a natural phenomenon I am about to define it. But I feel bound first to pay to Mathieu de Dombasle a testimony of high and respectful esteem, for the fruit of his unsuccessful attempts furnishes me with the first elements of my demonstration.

When employing figures we must always give a strict account of their value. I am about to employ those of Mathieu de Dombasle, which are no longer applicable to our situation. You will, therefore, kindly consider them as a means of putting my thoughts into words, or, if you prefer it, as symbols only. Mathieu de Dombasle takes us back to the earlier part of the century, but we are approaching its end.

It is very plain that the situation has changed. But as the elements of his accounts are not disputed—as everyone knows them—what does it matter to us that they have been drawn from a situation different from ours, if in passing from one term to the demonstration of another I succeed in explaining to you our proposition?

Here is a table which sums up the outlay involved in the cultivation of a hectare of wheat at Roville:—

COST OF THE PRODUCTION OF WHEAT AT THE INSTITUTE OF ROVILLE.

		Francs	Francs
Fixed expenses	Rent	45	186
	General expenses	52	
	Ploughing	43	
	Seed	46	
Fluctuating expenses	Manure	74	108
	Reaping, threshing, &c.	34	
	Total expenses		294
	Deduct for straw		50
	Remains		244

for 14 hectolitres, or 17½ francs per hectolitre.

You observe that the total disbursements amount to 244 francs per hectare and include outlays of two kinds, fixed and variable.

What do we call fixed outlays? The expenses which are independent of the result, that is to say, of the quantity of the crop. Whether the harvest is good or bad, rent and taxes must be paid. Consequently there are constant fixed expenses, unaffected by the result. This category further includes general expenses, the cost of ploughing and the seed.

At Roville, in the days of Mathieu de Dombasle, all these outlays united amounted to 186 francs.

Along with these fixed expenses there are also variable expenses, represented in the first place by manuring and the cost of reaping and threshing. It is evident that if you give the land forty cart-loads of dung per hectare, you expend more than if you gave only twenty. Consequently the outlay is here variable, and depends on the resources at your disposal. Mathieu de Dombasle computed the manuring at seventy-four francs per hectare.

Among the variable charges we must also include reaping and threshing. The expenses of the harvest and of threshing depend on the abundance of the crop. It is manifest that if you have reaped thirty hectolitres, you must pay more for threshing than if you reap only fourteen hectolitres.

Mathieu de Dombasle found the variable outlay 108 francs, which added to the fixed outlay makes up a total of 294 francs per hectare. If we deduct from this expense the value of the straw, estimated at fifty francs, the expense is reduced to 244 francs.

As the crop at Roville was fourteen hectolitres of grain per hectare, the price per hectolitre comes out as seventeen francs. At that time nothing but dung was employed as manure, which imposed upon the farmer the necessity of making the production of dung go on parallel with the production of crops. Dombasle therefore used nothing but dung, and thus, in spite of all his efforts, all his application, and all his improved instruments for the preparation of the soil, the quantity of dung which he produced being too little, he was not able to obtain more than fourteen hectolitres of wheat per hectare; a precarious yield which balanced the expenses with great difficulty. For beets and other crops the results were no better: he obtained scarcely 20,000 kilos. of beets per hectare, twelve hectolitres of colza, 4,000 kilos. of hay, and all the accounts showed a loss. Despite all his efforts, Dombasle could gain nothing. It is strange and truly touching to read the works of this worthy man, and to feel underlying his words a profound, inward sorrow, which he dared not or would not express. Having neglected nothing for success, and not seeing the cause of the evil, the failure overwhelmed him. More fortunate than he, I can show you this fatal cause. If in 1836, the date when Dombasle withdrew defeated from Roville, the doctrine of chemical manures had made its appearance—which would have been well for the Old World—I could have presented myself to Dombasle, and without further explanation have said to him, 'Beside all the efforts which you have made with such disinterestedness, one thing has escaped you. You believe that to obtain a fine harvest dung is absolutely needed. There is your error: in the first place, it costs you too dear, and you do not produce enough of it; to prove to you that we can do better and more cheaply without dung, permit me before your eyes to spread these six sacks of chemical manure over a hectare of your land.'

What would have happened? It is very simple. The outlay at Roville, as in the former case, would have been 186 francs in fixed expenses. The taxes, the rent, the general expenses, would have remained the same. But, whilst Dombasle used only seventy-four francs' worth of dung, I should have made him use, besides the dung, 120 francs' worth of chemical manure, i.e. 192 francs for the total manure, and the final result would have been as follows: the total expense, deducting the value of the straw, would have been increased from 244 to 345 francs; but in place of fourteen hectolitres of wheat he would have reaped thirty-one, which would have reduced its cost price to eleven francs per hectolitre instead of seventeen.

Production of Wheat upon a Clean, Well-manured Soil.

			Francs
Fixed outlay, as above			186
Variable outlay	Manure	194	254
	Reaping and threshing	60	
Total expenses			440
Deduct for straw			95
Remains			345

on 31 hectolitres, or 11 francs per hectolitre.

The explanation of the change will appear to you spontaneously.

If, by the intervention of a supplementary dose of manure, costing 120 francs, I increase the yield by seventeen hectolitres, the fixed expenses are divided among a larger number of hectolitres, and the cost price per hectolitre diminishes in a proportion corresponding to the increase of the crop.

If the doctrine of chemical manures had been known at that time, Dombasle, who prepared his land with extreme care and economy, would have been the grand patriarch of agricultural success. To-day he is merely a great moral authority, who, not having succeeded, has at least given us the means of avoiding the shoal upon which he was lost.

When you cultivate you have not to say, I must produce dung; but, I must give to the soil the sum of the agents of fertility which the crops require, in order to obtain for each the maximum yield. To have a profit it is necessary that the fixed charges—rent, imposts, ploughing—may be distributed over the heaviest possible crop, in order that the cost of production per hectolitre may decrease in the same proportion as the increase of the product. This is the rule. The question of dung is quite secondary, especially as we now know to what the dung owes its activity.

What would you say of a metallurgical company which supplied itself with fuel by means of forests created and maintained at its own expense instead of establishing itself on a deposit of coal? Like coal, chemical manures exist as minerals in the bowels of the earth, and you still seek to condemn yourselves to accumulate dung! You persist in taking the accessory for the principal! Why cling to the forest, the wood from which is so costly, when you have beds of coal at your feet, and when it merely depends on you to work them in order to extend on all sides abundance and wealth? To cause agents hitherto neglected to come into circulation, to raise the productive power of man, is to give to your country the equivalent of a province, and to the world the equivalent of a new continent if the increase of production becomes general.

The insufficiency of manure is not the only cause of failure against which it is necessary to be on our guard; there are two or three others more or less known to practical farmers, but which, unfortunately, too often escape the notice of men of a higher class who engage in cultivation.

Upon the second cause of failure I must insist more strongly than upon the former, because if it is known in an intuitive manner it has not been yet defined with sufficient strictness. I have discovered its importance at my own cost, and what we learn by losing money over it is not only not forgotten, but we know how to tell it, so as to carry conviction to others.

Knowing by long experience that advantage may be drawn from chemical manures, I had the imprudence to believe that it was sufficient to give to a manager a plan of cultivation and to leave it to him to be carried out.

But this is what happened. Instead of being prepared with the needful care, as I had directed and expected, the land was dressed very imperfectly. But as these fields had received manures of great power it was not a crop that was obtained, but heaps, I might say mountains, of weeds. Beware, therefore, of having recourse to chemical manures upon a soil which has been ill-prepared. The weeds gain the upper hand of necessity, and the crop thus contaminated will be a worthless product reduced to zero.

Note that for each kilo. of carbon which the weeds derive from the air one and a half horse-power day is working against you; for 2,000 kilos. of weeds there are 3,000 horse-power days counteracting and annulling your efforts.

To render this more easily grasped, it will be sufficient to place before your eyes the table of expenses of cultivation taken from Dombasle, supposing the soil well-manured, but alternately clean and foul with weeds.

First Case.—The soil is clean and well-manured. We expend 345 francs to reap thirty-one hectolitres, which brings the production cost to eleven francs per hectolitre.

			Francs
Fixed charges, as before			186
Variable charges	Manure	194	254
	Reaping, &c.	60	
	Total outlay		440
	Deduct for straw		95
	Net outlay		345

$\frac{345}{31}$ = 11 francs per hectolitre.

Second Case.—The soil is well-manured, but badly prepared and choked with weeds. The straw is thus rendered unsaleable, and the cost of cultivation reaches 440 francs per hectare, instead of 345.

The crop being fourteen hectolitres instead of thirty-one, the price per hectolitre amounts to thirty-one francs, or 37.20 francs per metric quintal!

PRODUCTION OF WHEAT UPON LAND WELL-MANURED, BUT CHOKED WITH WEEDS.

			Francs
Fixed charges, as before			186
Variable charges	Manure	194	254
	Reaping and threshing	60	
	Total outlay		440
	Nothing deducted for straw on account of its bad quality		—
	Net outlay		440

$\frac{440}{14}$ = 31 francs per hectolitre, or 38¾ francs per metric quintal.

We may carry the demonstration still further. Suppose that, instead of the 440 francs which were expended at Roville, we take the cost in our own days in a farm in the neighbourhood of Paris, where it reaches 700 to 800 francs per hectare, and that, in consequence of weeds, the crop, represented by 12,000 kilos. of dry matter per hectare, yields finally merely twenty hectolitres of wheat—which on many farms would be a good yield—and straw, which is not saleable on account of the weeds; the production cost of the wheat is raised to thirty-seven francs per hectolitre, or forty-six francs per metric quintal.

Here are the particulars:—

COST OF CULTIVATION IN THE NEIGHBOURHOOD OF PARIS.

	Francs
Rent	125
Preparation of the soil	200
Manure	200
Reaping and threshing	80
Carriage	25
Interest and sinking fund	50
General expenses and taxation	50
Unforeseen expenses	15
Total	745

$\frac{745}{20}$ = 37 francs per hectolitre, or 46 francs per metric quintal.

On the contrary—

The Land is Well-prepared and Freed from Weeds.

	Francs
Expenses, as above	745
Deduct for 3,000 kilos. straw	150
	595

If we reap 35 hectares, $\frac{595}{35}$ = 17 francs per hectolitre, or 21 francs per quintal.

If we reap 40 hectares, $\frac{595}{40}$ = 14.90 francs per hectolitre, or 18 francs per quintal.

If we reap 45 hectares, $\frac{595}{45}$ = 13.22 francs per hectolitre, or 16.52 francs per quintal.

Consequently, if the earth is not properly prepared, in spite of the use, or, I might rather say, in consequence of the use, of a powerful manure, we sustain a heavy loss, the weeds choking the crop.

This error I have committed, or, rather, it has been committed at my expense, and I have paid for it. What would you have? I had previously operated in the experimental field of Vincennes, where my orders are faithfully executed and supervision is easy; but my farm is fifteen leagues from Paris; I can go there but rarely; and the plan of cultivation which I had drawn up had not been followed.

A management without honesty has caused all the mischief, but we must leave bad faith on one side, looking merely at the fact, and laying down as a rule without exception, that land well-manured but badly prepared leads to ruin even more rapidly than land well-prepared but insufficiently manured.

At Roville the land was well-prepared, but insufficiently manured; at Bilbarteault it was well-manured but badly prepared. In each case the result was the same, proving that success and failure depend on primordial causes, absolute, unbending, superior in their effects and their expression to the action of man, of which they are, nevertheless, the consequence.

Let us not cease to repeat, Dombasle did not succeed because he did not give the soil enough manure. In 1881, at Bilbarteault, I was not more fortunate because the soil was infected with weeds. It is, therefore, not enough to manure the soil; it is necessary to make sure, by a due preparation, that the crop will get the benefit without weeds causing you to lose the fruit of your outlay and depriving you of the legitimate result of your efforts.

Note how these propositions differ from the precepts of the past. The memoir of Dombasle on the causes of success and of failure in agricultural undertakings is, as I have already pointed out, a code of precepts which chiefly regard men; the primordial conditions of cultivation do not come into question. He sees and concerns himself merely with the prudence and the foresight of the head of the undertaking, with the art of properly directing the subordinates. He is engaged with everything except the production of crops, definite in its causes, its agents, and its laws. My system is quite different. I intentionally set aside men; I disregard incidental causes. I see in the act of production merely a natural phenomenon; in plants and animals I see beings which must reach a certain development to yield a profit; I assimilate these beings to veritable machines, of which I define at the outset the working and the good conditions of production without occupying myself with the shortcomings of men, whether involuntary or intentional, and with the profit or the losses thence resulting. All these disturbing influences, which may become disastrous, I set on one side, so that I may see merely the fact of production in its imperative and absolute demands. The counteraction springing from human intervention will be taken into consideration at the end of this lecture. At present my sole mark is the crop, the final object of our efforts. Here you will perhaps tell me that all this is still theory, and that theory concerns you little. Beware, gentlemen, of uttering a blasphemy!

When a man consents to lose money in order to solve a complex and difficult problem, which can be expressed only in a theoretical form, so as to give his words that degree of generality on which their usefulness depends, to reject the counsels of theory is to misunderstand the imprescribable rights of reason and experience. In the special case which engages us do not forget that theory alone can lay down and define the means to which we must have recourse to avoid the dangerous contingencies which I have pointed out, and which unfortunately are not the only ones of their kind. There are still two or three more, one of which is more general than the two others.

This third cause may be formulated thus :—

Every system of cultivation which employs as manure merely the dung produced on the land, with hay derived from unmanured meadows and consumed in the stalls, is a system incapable of yielding profit, and must be absolutely proscribed.

The axiom 'meadow, cattle, cereals,' which sums up the economy of the system, is heresy and nonsense. If we discuss the balance-sheet of a farm worked on this system we soon perceive that the enemy is the dung, for the meadows and the cattle are mere encumbrances, which neither gain nor lose anything. On a farm of 100 hectares there are fifty hectares of meadow, which gain nothing; the capital represented by the stock and the meadow is dead capital; a fact expressed by saying that cattle are a necessary evil. In this system the hay, to admit the truth, is merely an organ of transit, but nothing more.

On this point no contestation is possible; to prove it I will cite one only instance, a single one, but it is as sufficient as it is decisive.

Here is the balance-sheet of the farm of Bechelbronn, at the time when M. Boussingault was at once the proprietor and the manager of a celebrated exploitation, but where dung was still the only manure employed.[1]

Balance-sheet of the Farm of Bechelbronn.

The operations are conducted exclusively by means of dung.
The articles consumed are valued at the price of production.

CHAPTER I

Crops

	Francs		Francs
Rent	4,500.00	Vegetable products sold	11,045.87
Expense of cultivation	5,340.46	Vegetable products consumed	5,197.20
740 tons of dung at 5.20 francs	3,702.61		
Profit to balance	2,700.00		
	16,243.07		16,243.07

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[1] I leave purposely untouched the operations where industrial refuse is available. The question would take us too far.

CHAPTER II

CATTLE

	Francs		Francs
Feeding	11,900.40	Animal products	12,961.50
Other expenses	6,071.30	Day's work	1,307.59
		710 tons of dung estimated at 5.20 francs to balance	3,702.61
	17,971.70		17,971.70

CHAPTER III

MEADOWS

	Francs		Francs
Rent	5,410.00	1,837 metric quintals of hay consumed at 3.60 francs (cost of production)	6,613.20
Expense of cultivation	2,415.45	325 metric quintals sold at 5.50 francs	1,845.25
Profit as balance	633.00		
	8,458.45		8,458.45

SOURCES OF PROFIT

	Francs
Crops	2,700.00
Hay sold	633.00
Total	3,333.00

Was there ever a more striking demonstration? How persuade ourselves that a difference of 3,000 francs between the receipts and the outgoings is really a profit?

Let us say, and say it loudly, that this defective and tottering system is the great cause of the evil.

Cultivation by means of hay is not remunerative. Most of the other causes of failure are its consequences.

This situation explains the difficulties with which agricultural industry struggles or has struggled down to the last twenty years.

Reflect on this constitution—

Meadow : . . . Necessity, no profit.
Cattle : . . . Necessity, no profit.
Results :
Crops : Ill-manured, no profit.

From all this it follows that besides human action and its defects, and besides commercial questions, there are three causes capable of ruining an agricultural undertaking : —

1. Insufficient manure.

2. Insufficient preparation of the land and consequent invasion of weeds.

3. Exclusive use of dung derived from meadows not manured, the hay of which is consumed in the stalls.

The proof that cultivation gives satisfactory results when these three causes are divided is furnished us by the great experiment of Mr. John Prout.

All the English agricultural journals tell us that for twenty years Mr. Prout has cultivated 180 hectares always in wheat with chemical manures, to the exclusion of all others, and that he has realised good profits. The cultivation is effected by steam; the crops are sold by auction as they stand, and for twenty years the mean yield of the crops has been thirty-six hectolitres. During this period the proprietor has obtained three and a half per cent. interest on the cost price of the land, five per cent. on his outlay of every kind, and after the lapse of twenty years his land has increased in value by 375,000 francs.

Here, then, is no dung, no weeds—chemical manures employed in the needful quantity. Result: A striking success.

It is true that this procedure cannot be put forward as a model to be followed, for in France and in Belgium prevailing customs are not adapted to the sale of standing crops, and the land is too much subdivided for the use of the steam-plough.

Admirable as a proof of the correctness of our principles, the experiment of Mr. Prout is not a solution. To be practical we must have the work executed by animals fed on the farm, but here the problem becomes complicated and you will learn how far agriculture is removed from the simplicity and independence often ascribed to it, and how rapidly an agricultural enterprise may be ruined if the mechanical work is ill-applied.

The rock which I point out to you, gentlemen, is that on which persons strange to cultivation suffer shipwreck, be they engineers, manufacturers, financiers, or savants, who reason by analogy from what passes in industry and imagine that there is a simple and direct relation between the work of the labourer and the product of the crop.

Here the danger is so much the greater, as everything which surrounds you conspires to plunge you into it. The born farmer ignores the theory of the danger which I have been explaining, but he excels in pushing you into it. The jealousy of the agricultural class against the proprietor is not inferior to the ferocity of wild beasts, and when by mendacious counsels they have enticed you to try a *coup de force* which cannot succeed you may read on their faces, underneath the mask of an assumed good-nature, the satisfaction with which they regard your ill-success—the hatred of the savage against the civilised man!

It took me two years to perceive and define in its essence this cause of failure, the most general of all. To analyse it and to follow out its ultimate consequences an entire lecture would be needed. Compelled to restrain myself, I must try to sketch it in its main features.

I will suppose that, after the example of Mr. Prout, you wish to cultivate wheat to the exclusion of every other crop, but without any other source of power than the animals maintained on the farm, and I take as instance an area of 100 hectares.

The preparation of the soil can begin only about August 15, a time when the harvest ought to be ended, and it lasts to the end of October, the completion of the last sowings. The work ought to be accomplished, seed-time included, in seventy-five days.

But if we deduct Sundays, holidays, and days of bad weather we find this number reduced to sixty.

To give the land a first ploughing for the removal of stubble, to harrow, to plough again a quarter-metre in depth, to harrow again, to cart the dung or chemical manure, to spread it and to sow the land—all this is in round numbers equivalent to four ploughings of a quarter-metre in depth. This is finally equivalent to a surface of 100 hectares ploughed once.

Now a plough drawn by three horses turns up on an average half a hectare daily; at this rate it will be needful to plough a mean total of seven hectares daily, and for that we must have at disposal in round numbers fourteen ploughs and forty-two horses for the preparation of 100 hectares.

When the corn is once sown, what are we to do with the beasts of burden and the men? Sell and dismiss? Is this possible?

What can be expected from workmen who know beforehand that they will be dispensed with?

The exclusive cultivation of wheat is not, therefore, practicable by the autonomous power of the farm except at a ruinous price.

We come thus to a novel conclusion, that in agriculture we cannot do what we please; the land cannot be treated like a conquered country.

The soil and the crop have imperative demands upon which we must reckon.

In countries like France and Belgium, where the land is extremely subdivided, we cannot apply the procedures customary in England, where, I repeat, there are powerful combinations for steam-cultivation.

The exclusive cultivation of autumn wheat by means of animals being thus admitted to be impossible or decidedly ruinous, a second case presents itself: divide the land into two large plots of fifty hectares each, one for spring wheat and the other for autumn wheat. In this case you have at your disposal not sixty, but at the least 150 days; this permits you to reduce the number of ploughs from fourteen to seven, and that of horses from forty-two to twenty-one.

This procedure is evidently better than the former. Yet it also is too burdensome for practice, for when once the autumn wheat is sown the number of draught animals is too considerable for the work during winter and spring.

We are, therefore, again driven to the alternative of reducing the men and the beasts of the farm, or of sinking under the burden of expenses out of proportion to the end in view.

To avoid this twofold quicksand, practice has recourse to a third procedure.

Instead of dividing the land into two portions it is divided into three of thirty-three hectares each.

The first lot is left in fallow, the second is cultivated with autumn wheat, and the third with spring wheat.

The fallow fulfils the function of the fly-wheel in machines; it regulates work, allows you to avoid disorderly efforts and the resulting false manœuvres. By its instrumentality you have the entire summer to prepare the land intended for autumn wheat. The weeds can be rooted out at leisure, and the staff of draught beasts reduced without inconvenience, and though the surface under cultivation is less, the crop does not undergo a corresponding reduction. The reduction of outlay which this system permits you to realise ensures a considerable advantage as compared with the two former.

In this last system three or four ploughs are amply sufficient, and the horses may be reduced from twenty-one to nine or twelve.

This reduction in the number of ploughs is not determined merely by that of the area cultivated, but by the increase in the number of working days, which is raised from 150 to at least 300, as the land left fallow may be prepared from June to the end of September.

This third method marks out one of the greatest advances which agriculture has ever effected. From it dates the triennial rotation, that is, the introduction of a regular method of working.

What a contrast between the products and the agricultural constitution of the three systems:—

		Ploughs
1st *System.*—	Exclusive cultivation of wheat	14
2nd „	Alternate cultivation of autumn and spring wheat	7
3rd „	Triennial rotation	4

The first system means ruin; the second is a precarious condition, with exorbitant outlay and an undisciplined staff. With the third system, on the contrary, we have order and security, with a staff small in number and the outlay reduced to the lowest limit.

Still this system, like all the rotations which have been derived from it, has a fundamental vice.

If the farm is to be self-supporting, we must add to the arable land an equal area of meadow.

To a cultivated tract of 100 hectares we must join as support 100 hectares of meadow, in order to have dung—a painful necessity, since we have seen that meadows and cattle are real burdens, and that with dung alone we obtain merely poor crops.

How are we to escape from this apparently inextricable net?

The means are very simple. Let us break with all traditions, and begin by dissociating the meadows from the arable land. We render them independent of each other. The meadow is no longer destined to produce dung. Instead of making it the source of manure, we manure it plentifully, and in place of using it for mowing, we give it up to the cattle as pasture; we convert it thus into an independent culture destined to produce meat, which allows us, without care or trouble, and almost without labour, to arrive at a profit of 300 to 400 francs per hectare.

To effect so fundamental a reform it is merely needful to use per hectare 600 kilos. of the homologous manure No. 1:—

	Kilos.
Superphosphate	200
Potassium chloride	100
Ammonium sulphate	195
Gypsum	105
	600

Let us once more repeat it: with pasturage the expenses of cultivation are reduced almost to nothing; the animal effects the reaping, its excretions renew the manure, and to keep up fertility it is sufficient each year to apply a moderate dose of chemical manure to compensate for the losses occasioned by the sale of meat. Conclusion : progressive fertility, profit secure, suppression of a portion of human labour, simplification of the operations; such is the purpose and such is the result.

Here, gentlemen, let us pause, and from respect for science, at the risk of repeating ourselves to some extent, let us give this result its philosophical expression.

In the meadow man works, in the pasture the animal works, or rather the sun. In fact grass is for the animal what coal is for the locomotive, the source of its activity and of its functions. To ascend Mont Blanc a man has to burn in his system 350 grammes of carbon; to graze the pasture and acquire a kilo. of living weight an ox has to burn 1 kilo. 33 grammes, which represent two horse-power days or four days' work of an ox, the mechanical work of which is the ploughing of half a hectare.

Even if the number of oxen is forty or fifty, the price of mechanical work is reduced almost to 0. For this it is sufficient to let the oxen work half a day during one week, and leave them to rest during the next week. A kilo. or two of oil cake given in addition to their food during the period of work prevents their fattening from being impeded. And then the pasture substituted for the meadow becomes with reference to the sun the equivalent of an accumulator, in which the stored-up energy generates at once meat and mechanical work by the intervention of a second accumulator of a higher order, the ox, the substance of which becomes in turn one of the sources of human energy. The man who moves, fights, or thinks, derives the faculty and the means from the flesh of the ox, or more generally from his food.

Pasturage and its derivatives are in reality the affirmation in all degrees of the laws of life, from the depths of the starry world to the least movement of the humblest larva.

A dazzling vision, destined by its resulting applications to form the ultimate and most solid basis of agricultural progress; and hence we return to practice.

Grass-land converted into an independent cultivation, without expense, and producing meat—this is the solution of the first term of the agricultural problem. It may be summed up in one line: *Manure the meadows chemically and convert them into pasture.*

We pass to the second term of the agricultural problem, the cultivation properly so called. In the three-years' system, to 200 hectares of land there are 134 hectares of no value—100 in the state of meadow, which gain nothing, and thirty-four hectares of dead fallow, the only utility of which is the better to secure the preparation of the soil.

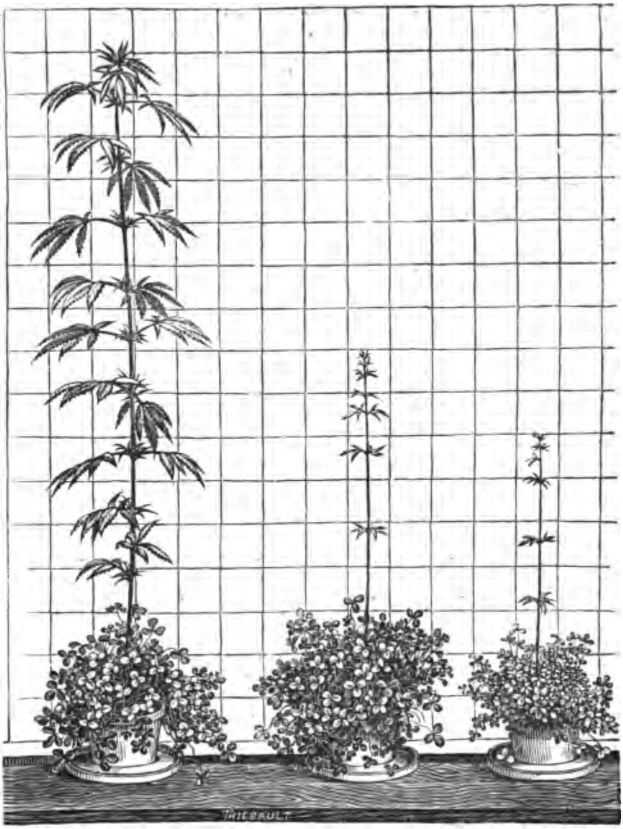
On this point the reform which I propose is neither less profound nor less complete than that of the meadow. In place of leaving the fallow in a dead state, we will use it to produce manure without passing through the systems of animals, which effects an economy of at least 100 francs per hectare. Thanks to an artifice which I am about to point out, we convert the fallow into a veritable manure-pit without in any way losing its utility for destroying the weeds, and for facilitating the preparation of the soil.

Let us speak of the means of obtaining this result.

You know, gentlemen, that plants are divided into two classes: those which, like the cereals, require to receive nitrogen in manure, and those, of which clover is the most perfect type, which draw by preference nitrogen from the air in the state of gas.

For ten years I have been accustomed to sow each year at the experimental field of Vincennes clover along with hemp and wheat, and each year I

Clover along with Hemp



Complete Manure Mineral Manure only No manure find that in the plot which has received the complete manure the wheat and the hemp are very fine, and the clover only moderate. On the plot which had received mineral manure without nitrogen the clover is splendid, whilst the hemp and the wheat are poor, yellow, and ill-developed.

—	Complete manure with nitrogen	Mineral manure without nitrogen	Soil without manure
	Green Crop		
	Grammes	Grammes	Grammes
Clover . . .	64·510	112·310	40·840
Hemp . . .	44·485	0·378	0·137
	108·995	112·688	40·977
	Dried Crop		
Clover . . .	12·498	20·573	8·169
Hemp . . .	13·985	0·300	0·114
	26·483	20·873	8·283

To diffuse in the agricultural world this twofold affirmation I had the idea of repeating the same experiment in pots, operating with earth taken from the field at Vincennes, in plots which since their formation had received complete manure or mineral manure without nitrogen.

The same experiment was made in 1888 by M. L. Dumont, in one of the experimental fields connected with the great agricultural establishment at Chassart. M. Dumont obtained the same results as those recorded at Vincennes, and he has communicated them to me.

EXPERIMENTAL FIELD AT CHASSART

—	Crops per hectare		Mean height
	Green	Dry	
	Kilos.	Kilos.	Cm.
Intense manure with 100 kilos. nitrogen . .	19·300	7·810	43
Complete manure with 75 kilos. nitrogen . .	19·800	8·650	47
Mineral manure without nitrogen . . .	30·100	10·038	64

You will tell me, possibly, that this great fact is contested. We will not stop at this trifle; let us imitate the philosopher who, to prove the possibility of motion, got up and walked. Before leaving this hall let us collect the facts of practical experience which are inscribed upon these tables, and which tell you that with calcium phosphate, potassa, and lime, without traces of nitrogen, the leguminous plants clover and lucerne give a better crop than do the same substances with the addition of nitrogen. You perceive further that these three substances, so efficacious in case of clover, are of very little use as regards wheat, but become at once efficacious if associated with a nitrogenous matter, such as ammonium sulphate or sodium nitrate. Collate these assertions, which do not originate with me, but which I have verified, enlarged, and utilised. I do not discuss these facts, which I am prepared to defend when the moment shall have come; I confine myself to reminding you of what you all know, that a crop of wheat which follows after clover is more productive than one which precedes it, though the former had been manured and the second not. Have not the experiments carried out on the trial-field of Vincennes moreover established that the nitrogenous compounds so useful for wheat are useless for clover? that certain vegetables derive their nitrogen by preference from the air?

Seizing hold of this fact, I had the idea of using the fallow for an 'intense' cultivation of clover, one or two cuttings of which I had ploughed in deeply.

To estimate the bearings and the character of this innovation it must be defined in its least details.

The clover which is to occupy the land is sown along with the wheat. There, without injuring the latter, it smothers the weeds. In autumn the land is harrowed violently and receives per hectare 1,000 kilos. of the incomplete manure No. 6—that is, the mineral manure without nitrogen:

	Kilos.	Francs
Superphosphate	400	48
Potassium chloride (80 per cent.) .	200	36
Gypsum	400	8
	1,000	92

This is a rich dressing, and in consequence the clover takes an extraordinary development, reaching the height of more than one metre. The crop is from 30,000 to 40,000 kilos. per hectare if we take the roots into account, the whole containing 250 kilos.—not to say 300 kilos.—of nitrogen. In June it is laid down by means of a heavy roller, and dusted over with 400 to 500 kilos. of powdered quicklime, awaiting suitable weather for ploughing it in. In moist years we may, to utilise the second cutting, mow the first and make it into a heap with a batter of ten to twelve metres; when the soil is sufficiently moistened and the second crop advanced enough it is rolled; the first crop is then spread over the second, and both are ploughed in to the depth of one-third of a metre.

The cultivation of clover thus conducted possesses all the advantages of a fallow; it allows of the soil being prepared at times when the horses are not occupied, from June to August; it considerably reduces the cost of tillage, as the land which has produced clover requires only one ploughing, whilst a dead fallow needs at least three. But the grand result is that clover enriches the land to the extent of 250 to 350 kilos. of nitrogen, which, when associated with the mineral matters of the chemical manure, convert the incomplete manure No. 6 into the complete intense manure No. 1, fit for the production of cereals. In this item alone the land gains 300 to 400 francs per hectare, to which must be added an economy of 60, if not 100 francs per hectare in the cost of preparation.

The fallow thus becomes a true manure-pit, and this manure, being made on the spot, requires neither the cost of carriage nor that of preparing and spreading. The amelioration of the soil cannot be denied, since there is introduction of the mineral substances and of nitrogen.

Every objection is answered. The nitrogen comes from the air; the soil has not been able to furnish it, since if left to its own resources it would not have yielded more than ten to fifteen hectolitres of wheat per hectare, and since 40,000 to 50,000 kilos. of clover, produced with 1,000 kilos. of mineral manure, are worth more than 50,000 kilos. of farmyard dung; for with the latter you draw the nitrogen and the minerals from the meadows, whilst under the new system the inorganic matters are obtained from the mineral wealth of the globe. We import potash, phosphates, and gypsum, and we use the *vis viva* of the sun to force the nitrogen of the air into the tissues of the clover, the production of which merely requires the minerals which I have named.

When the clover is thus obtained I call it *sideral manure*, to mark its origin and its mode of formation. You know that to cart and spread 50,000 kilos. of dung involves an outlay of 100 francs, and for this sum you may obtain the mineral portion of the sideral manure.

Without the sideral manure the earth would have yielded per hectare fourteen or fifteen hectolitres of wheat, but with its aid the yield is forty to forty-five.

The supposed yield of forty hectolitres is a minimum. Upon land prepared by sideration we may expect yields of fifty to sixty hectolitres, always on condition of selecting with discernment among the most productive varieties those best suited to the locality cultivated.

Sufficient attention has not yet been given to the choice of seed.

On the same soil and with the same manure the crop may vary in the proportion of one to two. We may judge by instances given in the Appendix, and which result from recent experiments made at Roville, under the care of M. Thiry, manager of the Dombasle farm.

Dung costs fifteen to eighteen francs per ton, and requires you to sink 700 to 800 francs per hectare for a dressing of 50,000 kilos. The sideral manure costs five to six francs per ton, and requires you to sink merely 200 to 300 francs, the cost of the minerals and the rent of the land. Its preparation does not depend on stock; at the same time you suppress the cattle fed under conditions which render them nuisances, and you simplify the preparation of the soil, which under this head alone means a saving of 60 to 100 francs per hectare.

Let us further insist, and fix with more precision the cost of the sideral manure, or rather of the chemical manure for which clover furnishes the nitrogen.

The cost is made up of the value of the minerals, phosphate, potash, and gypsum, of the rent of land, and general expenses. Let us again take the Institute of Roville as an instance:—

	Kilos.	Francs	Per hect. Francs
Superphosphate	400	48	92
Potassium chloride (80 per cent.)	200	36	
Gypsum	8	8	
Rent of land		45	97
General expenses		52	
Total			189
Per year			94½

To obtain 40,000 kilos. of sideral manure—that is, 4¾ francs per 1,000 kilos.

If we have to sell a part of the straw of the crop, the dose of the minerals must be doubled, which will raise the expense to 281 francs for two years; but what a manuring!

On the former supposition, the expense for 100 hectares would be 6,293 francs, and 9,357 francs for the second.

When the cultivation of cereals is continuous, without intermittence, and we limit ourselves to the rotation of autumn cereals and spring cereals, we cannot spend less than 200 to 220 francs yearly per hectare.

For 100 hectares 20,000 francs.

Cost of Manure for 100 Hectares

	Francs
1. Continued culture of cereals	20,000
2. Ditto by sideration	6,293
3 Ditto by intense sideration	9,357

The economy is from 10,000 to 14,000 francs, according as the sideration is simple or intensified.

It remains to speak of the produce, of the value of the crop under the three sets of conditions mentioned: the exclusive cultivation of wheat with chemical manures; the alternating cultivation of autumn and spring wheat, also with chemical manures; and, lastly, the same alternating cultivation according to the sideral system.

The exclusive cultivation of wheat, when the soil is prepared by animal labour, does not yield more than twenty-eight to thirty hectolitres per hectare. Wheat, after clover ploughed in—that is to say, by sideration—produces forty to forty-five, which may thus be summarised for the three systems:—

1st Case

	Ploughs
100 hectares of autumn wheat	14

Products

	Francs
100 hectares of autumn wheat at 28 hectols. per hectare = 2,800 hectols. at 20 francs . .	56,000
150 francs worth of straw per hectare . .	15,000
	71,000

2nd Case

	Ploughs
50 hectares autumn wheat	7
50 hectares spring wheat	

PRODUCTS

	Francs
50 hectares of autumn wheat at 30 hectols. per hectare = 1,500 hectols. at 20 francs .	30,000
150 francs of straw per hectare . . .	7,500
50 hectares of spring wheat at 30 hectols. per hectare = 1,500 hectols. at 18 francs .	27,000
150 francs of straw per hectare	7,500
	72,000

3RD CASE

		Ploughs
33 hectares	autumn wheat	4
33 ,,	spring ,, ...	
34 ,,	clover	

PRODUCTS

	Francs
33 hectares of autumn wheat at 40 hectols. per hectare = 1,320 hectols. at 20 francs .	26,400
200 francs of straw per hectare	6,600
33 hectares of spring wheat at 30 hectols. per hectare = 990 hectols. at 18 francs . .	17,820
200 francs of straw per hectare	6,600
	57,420

SUMMARY OF PRODUCE

	Francs
1st Case	71,000
2nd Case	72,000
3rd Case	57,420

To give its effective value to the produce of the sideral rotation, we must remark that the outlay is at least 20,000 francs less than in the two other systems. Add the sum of these savings to the 57,420 francs of produce to render the terms comparable, and you obtain 77,420 francs as expression of the value of the crop given by the sideration.

COMPLETE PRODUCE OF THE 3RD CASE

	Francs
Produce	57,420
Economies, viz.:	
Manure	10,000
Seed	1,000
Three ploughs	9,000
	77,420

I repeat it, therefore, with the sideral rotation the outlay is smaller, the net produce higher, the harvest more certain, and the farm possesses a constitution which renders it proof against all attacks ; in the two other cases we have want of success, if not ruin, and chronic revolt.

In place of repeating the formula, 'Meadow, cattle, cereals,' you will say, 'Sideration, chemical manures.' Clover ploughed in involves no expense ; the nitrogen of the air costs you nothing beyond the rent of the land. It is easy for you thus to reach the ultimate limits of profit. Who can contest this advantage ?

But this is not all ; it offers the landlord unhoped-for opportunities for finding a farmer, for it offers the farmer, on entering into occupation, advantages which no other system can present. With a third of the land in clover, and the meadows converted into pasture, if the farmer possesses abundant stock he may come without apprehension; the clover and the after-growth supply these animals with abundant nourishment, and the soil is admirably prepared for wheat. The first year will be one of the most fruitful. If you wish to add a further advantage, and make for the farmer a real bridge of gold, sell him the crop of cereals as it stands, and leave him a considerable profit.

What greater chances of gain could be offered him? and what conditions were ever more favourable to the farmer?

Lastly, to carry the demonstration to its ultimate limits, I might show you how easily the sideral cultivation which corresponds to the triennial rotation lends itself to all the imaginable combinations of culture. But the plan which I have furnished is already too extensive. I must confine myself to laying down principles, and leave you the care of turning them to advantage and drawing from them their ultimate consequences.

To those who say that dung is always necessary, we reply, You are sincere, but you are mistaken. To those who say that meadows are necessary for good cultivation, we reply, You utter a heresy; the meadow permits us to husband the elements of fertility which the soil possesses, but, with the exception of a little nitrogen, it does not enrich the soil, but leaves it as it was found.

With the introduction of mineral manures the conditions are entirely changed. The phosphoric acid, the potash, and the lime brought from without are an increase of fertility. If we derive these same agents from the meadow, we do not enrich the soil, we merely utilise better what it already possesses.

Shall we make a last effort, the better to perceive the deductions from these new data? Suppose a soil deficient in phosphates. You merely employ dung as a manure. Consequently, you do not supply the land with phosphates. Your stock will be meagre; it is Bretagne of twenty years ago as compared with Normandy. You manure with dung, in which there is little phosphate; because the animal demands much, its reduced and angular skeleton tells a tale of its sufferings to all who can read this alphabet.

Is phosphate wanting? In consequence of this one fact all the other constituents of the dung receive an irremediable injury; phosphate is needed in order that the nitrogen, the potash, and the lime of the dung may manifest their activity. With the dung which has originated from a soil poor in phosphates you cannot give it in the needful dose. Another example: traverse the Department of Aveyron, where we find felspathic lands deficient in lime, and calcareous districts where it is superabundant. On the felspathic lands the animals are diminutive; the men themselves are small in stature and of angular forms; their very pronun ciation—who would believe it?—savours of a defect of lime. On the calcareous lands the stature of the inhabitants is higher, their frame more powerful, and their character more loyal. The conclusion is that lime should be brought to the felspathic lands, and phosphates and potash to the calcareous districts. You ignore these directions; very well, on the soils deficient in lime you are doomed to nourish yourselves on potatoes, and you will remain small, angular, stammering, &c. Your cattle will have little value, on account of their small size. How can the dung which comes from a soil deficient in lime remedy this situation, which is more powerful than you, and by which you are dominated and subjected?

You know, on the contrary, the laws of production and the elements which take part in it, and you know that the soil requires lime. You are ready to subscribe to this doctrine; immediately the organisation of the plants and the animals is modified; you realise important benefits: in place of being the slaves of circumstances which dominate you, you become rulers. Your organisation, which reflects that of the creatures on which it is nourished, rises in the biological scale, and you pass from an inferior to a superior race. You have realised your conditions of existence, and by your efforts, the fruits of long labour ennobled by unconscious sufferings, your organisation has been perfected. The knowledge of these sovereign laws will give to labour its recompense, to nations prosperity, and to governments as well as to peoples the first of all good things, security and tranquillity.

But the interests here involved require by their greatness and the importance of the results which they can furnish conclusions practical to the last item; a sort of code of what is to be done and is not to be done. This parallel between a triennial rotation and a sideral culture seems to me the most proper method for attaining this object, and for throwing light into your minds. Read, weigh, and decide for yourselves, gentlemen, in the plenitude of your impartiality.

Triennial Rotation	Sideral Rotation
Dead fallow. Wheat. Oats or spring wheat. Meadows, yielding 4,000 kilos. hay per hectare.	Clover manured chemically. Wheat. Oats or spring wheat. Pastures manured chemically. Produce, 600 kilos. of meat per hectare.
1. In the triennial rotation the meadows and the cattle are burdens imposed upon the farm for the sake of dung. They yield nothing.	1. In the sideral rotation the meadow, converted into pasture and manured chemically, becomes an independent cultivation, which yields at least 300 to 400 francs per hectare.
2. In the triennial rotation the hay and the aftermath must be mown, the hay be trussed and carried to the farm, which means at least an outlay of 100 francs per hectare.	2. In the sideral rotation there is no cost of hay-making, and the pasture yields more than the arable land.
3. In the triennial rotation if the hay is sold it must be carried to a railway station, which for a distance of only 8 kilometres and for 4,000 kilos. of hay represents an outlay of at least 30 francs per hectare.	3. In the sideral rotation the beasts walk to the railway station.
4. In the triennial rotation the crop which must be carried by rail is 4,000 kilos.	4. In the sideral rotation the crop despatched by rail is 1,200 kilos., at the rate of 600 kilos. for two heads of cattle.
5. In the triennial rotation the fallow requires three ploughings and numerous harrowings.	5. In the sideral rotation the soil needs only one ploughing. Economy of at least sixty francs per hectare.

6. In the triennial rotation the dead fallow yields nothing.	6. In the sideral rotation the fallow yields 40,000 kilos. of clover, containing 250 kilos. of nitrogen drawn from the air, and worth 300 to 400 francs.
7. In the triennial system you spend two francs per ton on carting and spreading dung.	7. In the sideral rotation nothing is spent for carting and spreading manure.
8. In the triennial rotation the fallow is a burden, yielding nothing.	8. In the sideral rotation the fallow is a source of manure equivalent to 40,000 kilos. of dung.
9. In the triennial rotation the dung, having the soil for its origin, may delay its exhaustion, but does not enrich it.	9. In the sideral rotation the mineral manure being imported, and the nitrogen drawn from the air, the soil becomes richer each year.
10. Farmyard dung is poorer than sideral manure in the item of nitrogen.	10. The sideral manure, richer in nitrogen than animal dung, is not less rich in minerals.

FARMYARD DUNG

	Per 1,000
Nitrogen	4·16
Phosphoric acid	1·76
Potash	5·00
Lime	10·00

SIDERAL MANURE

[*Clover dressed with chemical manures*]

	Per 1,000
Nitrogen	5·36
Phosphoric acid	1·30
Potash	5·00
Lime	9·60

11. In the triennial rotation you produce only 20,000 kilos. of dung per hectare, or 10,000 kilos. per hectare yearly, represented by:	11. In the sideral rotation you produce 40 to 50,000 kilos., in round numbers 25,000 kilos. yearly per hectare:

	Kilos.
N	82
P_2O_4	34
KO	100
CaO	200

	Kilos.
N	241
P_2O_4	59
KO	225
CaO	500

12. Farmyard manure, by the time it is spread upon the soil, costs fifteen to seventeen francs per ton.	12. Sideral manure costs scarcely five or six francs for spreading, not to mention the excess of lime given to the earth over and above what the clover has absorbed.
13. In the triennial rotation you produce fourteen hectolitres of wheat per hectare.	13. In the sideral rotation you produce forty to forty-five hectolitres of wheat per hectare.
14. In the triennial rotation after two crops of wheat the soil has gained neither nitrogen nor phosphoric acid; it has gained a little potash and lime.	14. In the sideral rotation after two crops of wheat the earth is enriched in nitrogen, phosphates, potash, and lime.
15. In the triennial rotation the dry seasons are calamitous; food for cattle is deficient, and the preparation of fallows involves great expense.	15. In the sideral rotation during dry seasons the clover furnishes abundant fodder, and ploughing in the second crop of clover, if carefully managed, as an exceptional stratagem is a safe substitute for the first.

The sideral rotation therefore yields economy, security, abundance of manure and remunerative crops, with labour reduced to the lowest limit.

In turn the sideral manure is advantageous by being richer in nitrogen. It is advantageous by the origin of its mineral portion, which is brought from outside in the form of chemical manures, and which increases the native fertility of the soil.

The present shows more profit, and the future an increase of security.

I repeat, gentlemen, it is for you to draw the final conclusion. It is of vital importance. By reacting upon the agricultural prosperity of the country, it can and must contribute more than any other solution to restore order in the mind, and to render possible for Belgium, without trouble, to take a new step in the way of prosperity, of liberty, and of civilisation. This is the wish which I form in leaving you, if, in the words of the man of science, your patriotism recognises the affectionate advice of a true friend.

At the end of M. Ville's lecture, the Count F. van der Straten-Ponthoz, Vice-President of the Society of Agriculture, rose, and expressed himself in these terms in thanks to M. Ville:—

'Never since this hall has been opened, since all the glories of Belgium have been painted upon its walls, since the Academy of all the Sciences has been established here, do I believe that any orator has ever held for three days so numerous an audience under the spell of his words and of his intelligence. I tender to M. Georges Ville our most sympathetic thanks, not on behalf of this meeting alone, but of the whole of Belgium, which is proud to welcome a man of such merit.

'M. Georges Ville has for many years withstood all difficulties and all labours. He has brought us not merely great theories in agricultural science, but also good practice. In fact, gentlemen, have you ever heard agricultural lessons of higher character and more fruitful? We know now what we ought to do with our meadows. No one has ever told us with such simplicity and such clearness. We know now how we may obtain from our lands remunerative crops, whilst permitting them to become enriched and to rest in the shelter of the leaves of clover.

'I have to announce to you another piece of good news: M. Georges Ville's lectures will be published in a separate volume. He wishes that his lectures, delivered at Brussels, should be published for the whole of Belgium. Let him, therefore, receive our thanks. The remembrance which he leaves among us is one which will never fade away.'

APPENDIX

At the close of the third and last lecture a great number of the audience requested M. Ville to publish the tables in which his principal arguments are summed up.

The Appendix has sprung from this request; it is the justification of the three lectures by facts.

FIRST LECTURE

This was devoted to the analysis of vegetable production, to the definition of its character, of the substantial elements which it brings into play, and of the *vis viva* derived from the sun.

By means of the tables which will follow, we have, for the first time, an exact indication of what vegetation derives from natural sources.

As regards substance, air and water yield nine-tenths of the weight of plants. As regards *vis viva*, we have proof that the sun is the motor of vegetable activity, the source of its productive power, the exhaustless focus destined to yield us the means of new action of an incalculable importance.

I

Composition of Plants

Plants are formed of fourteen elements, always the same, always united, always associated, that is to say :

ELEMENTS OF VEGETABLE PRODUCTION

Organic, 4	*Minerals*, 10
Carbon	Phosphorus
Hydrogen	Sulphur
Oxygen	Chlorine
Nitrogen	Silicon
	Iron
	Manganese
	Calcium
	Magnesium
	Sodium
	Potassium

At the beginning these fourteen elements are equally distributed among the different organs. The vegetable mass is homogeneous and uniform in all its parts, but in proportion as plants approach their inflorescence, there ensues a separation of the different elements. The proportion of carbon, hydrogen, and oxygen does not change, it remains uniform and constant in all the organs ; but the nitrogen, the phosphoric acid, the potash, and the magnesia become concentrated in the fruit and the seeds, whilst the silica, ferric oxide, sulphuric acid, and lime are localised in the roots, stems, and leaves.

We take as an instance of this unequal distribution the composition of wheat :

MINERALS

——	In 100 parts of Ash		
	Roots	Straw	Grain
Phosphoric acid	1·70	2·26	46·00
Magnesia	1·97	3·92	13·77
Potash	2·87	15·18	32·59
Lime	0·88	3·00	1·19

NITROGEN

In 100 parts of Crop		
Roots	Straw	Grain
0·79	0·4	2·94

II

Origin of Plants

Vegetables draw their substance from three different sources, the air, the rain, and the soil, of which the two former are much the more important. They give to plants ninety-five per cent. of their substance, whilst the soil gives scarcely five per cent.

This is the proportion of each of these three sources:

COMPOSITION OF WHEAT, STRAW, AND GRAIN. IN 100 PARTS

Carbon	47·69	93·55 derived from air and rain.
Hydrogen	5·54	
Oxygen	40·32	
Soda	0·09	3·386 with which the soil is superabundantly provided, and which do not need to be added.
Magnesia	0·20	
Sulphuric acid	0·31	
Chlorine	0·03	
Iron oxide	0·006	
Silica	2·75	
Manganese	(?)	

COMPOSITION OF WHEAT, STRAW, AND GRAIN. IN 100 PARTS

Nitrogen	1·60	3·00 with which the soil is provided only to a limited extent, and which require to be added as manure.
Phosphoric acid	0·45	
Potash	0·66	
Lime	0·29	

III

Financial Importance of the Support given to Plants by the Atmosphere

If we assign to carbon the price of coal at Paris, i.e. forty francs per ton, and to nitrogen the value which it bears in manures, that is, 1½ franc per kilo., we find that the crop of one hectare, taken at 10,000 kilos., has drawn from the atmosphere carbon and nitrogen of the value of 400 francs—i.e. 5,000 kilos. carbon, at fifty francs per ton, 250 francs; 100 kilos. nitrogen, at 1½ franc per kilo., 150 francs; total, 400 francs.

For the agricultural surface of France, the quantity drawn from the atmosphere reaches in round numbers the value of 5,000 millions:

Surface under cultivation	Hectares	Carbon absorbed, in tons	Nitrogen absorbed, in tons
Arable and meadows	30,659,254	41,910,000	1,530,000
Forests and viney'ds	9,776,334	18,320,000	350,000
Olive, almond, and mulberry grounds	109,261		
Chestnut groves	559,029		
Total		60,230,000	1,880,000
Value		2,400,000,000 fr.	2,820,000,000 fr.
Total value		5,220,000,000 fr.	

IV

Source of the Vis Viva which regulates the Production of Vegetable Substance

1 kilo. of carbon yields in burning . 8,000 calories
1 calorie . . . . . . = 424 kilogrammetres
8,000 calories therefore . . = 3,390,000 ,,
The work of a horse is expressed by . 270,000 ,, hourly
The day's work of a horse, being taken at 8 hours, is expressed by . . 2,160,000 kilogrammetres
But, as the combustion of 1 kilo. of coal produces 8,000 calories, equivalent to 3,390,000 kilogrammetres, the combustion of 1 kilo. of coal = 1½ day's work of a horse.

On the other hand:

If the assimilation of carbonic acid by plants requires the fixation of a quantity of heat equal to that produced by the combustion of the carbon:
For 1 kilo. of carbon assimilated plants consume a quantity of heat equivalent to . . . 1½ day's work of a horse
For 5,000 kilos. of carbon the equivalent is . . . . . 7,500 days' work of a horse
But as in preparing the hectare we expend only the equivalent of . 15 days' work of a horse
When man expends 1 in mechanical effort, nature adds an effort = 500 times his own.

V

Importance of the Vis Viva set in action by Vegetation

For 10,000 or 12,000 kilos. of crops the *vis viva* utilised is, in round numbers, 8,000 days of horse-power (steam), a horse-power day being equal at least to the day's work of five men.

FORCE UTILISED

Vis viva consumed	Days	
	Horse-power (steam)	Men
Per hectare	8,000	40,000
— 10 hectares	80,000	400,000
— 100 „	800,000	4,000,000
— 200 „	1,600,000	8,000,000

If we fix the whole human population at 1,200 millions, 33,000 hectares, or the third part of a French department, will require, to yield their crop, an effort, or a consumption of *vis viva*, equivalent to one day's work of the whole human race.

FORCE WASTED

———	Equivalent of days' work	
	Horse-power (steam)	Men
The sun gives in the course of a year, per hectare	2,000,000	10,000,000
Vegetation utilises	8,000	40,000
Vis viva lost, per hectare . .	1,992,000	9,960,000
— — 10 hectares	19,920,000	99,600,000
— — 100 „	199,200,000	996,000,000
— — 1,000 „	1,992,000,000	9,960,000,000

If we estimate the human population at 1,200 millions of inhabitants, we find that 150 hectares of land—that is to say, the extent of a private park—receive, over and above the force utilised by vegetation, the equivalent of one day's work of the whole human race; and that 33,000 hectares, or the third of a department, lose 220 days' work, or two-thirds the work of the human race for a year.

We may go further: if we take the territory of France at 50,000,000 hectares, we find that the *vis viva* lost in the course of a year equals the work of the human race for twelve centuries.

VI

Cost of the Day's Work of a Sideral Horse-power compared to a Steam Horse-power

The price of a sideral horse-power utilised by vegetation depends on the quantity of the crop, and it has for its expression the sum of the rent of the land and of general expenses.

At Roville these charges were, per hectare:

	Francs
Rent	45
General expenses	52
	97

The crop of grain being eighteen hectolitres per hectare, corresponds to a harvest of 4,500 kilos., in which carbon enters to the extent of 2,000 kilos.; this represents 3,000 horse-power, the price of the sideral horse-power utilised=0·03 franc.

But if by means of powerful manuring the quantity of the crop should reach 12,000 kilos., corresponding to

8,000 horse-power, the price per horse-power would fall to 0·012 franc.

Now the quantity of *vis viva* expended by the sun upon the surface of one hectare is 2,000,000 horse-power; whence the price per horse-power, if entirely utilised, would be 0·00005 franc.

You may hence judge how desirable it is to substitute by devices of cultivation sideral power for all other sources of energy in agriculture.

SECOND LECTURE

MORE practical than the foregoing, the second lecture comprises a full summary of the doctrine of chemical manures—

1. Proof that air and rain take part in the production of plants.
2. Proof that calcined sand may be made equal in fertility to good soil by means of certain chemical products.
3. The law of dominants justified by incontestible proofs.

This part of the Appendix contains besides:—The history of all the chemical products which enter into the composition of manures.

The determination of the cost of chemical manures as compared with that of dung.

Catalogue of the principal manures proposed by the author, and the rules according to which they should be employed, whether upon single crops or upon crops in rotation. In support of these theoretical theses there are adduced a great number of results obtained on the experimental field of Vincennes, which have not hitherto been published.

Cultivation in Calcined Sand

In this paragraph results are arranged so as to show the principle of accumulative results and the law of dominants, and to this end we take as our departure the crops obtained in calcined sand.

CULTURE IN CALCINED SAND

Seed	Weight
20 grains of wheat	1 gramme
Crop	
Without any manure	6 grammes
With minerals	8 „
— nitrogeneous matter	9 „

Principle of Accumulation

This principle may be thus embodied :—Two or more substances being associated, produce an effect superior to the sum of the effects of each if employed singly.

Example :—

HARVEST IN SAND

		Excess	
Without any manure	6 grammes		
With minerals	8 „	2 grammes	5 grs.
— nitrogenous matter	9 „	3 „	
— nitrogenous matter and minerals jointly	22 „	16 „	

The sum of the excess of crop produced by the nitrogenous matter and the minerals separately is 5 grammes; when they are associated the excess is 16 grammes.

Association adds, therefore, to the effect of each substance employed separately. This is the principle of accumulation.

The Dominants

If there is given a field of wheat and we increase the dose of minerals, the effect upon the crop is *nul*; the quantity of the crop is not increased.

But if we augment the dose of nitrogenous matter, the quantity of the yield increases in a corresponding proportion. On account of this functional pre-eminence, we call nitrogenous matter the *dominant of wheat.*

Experience teaches us that this pre-eminent and governing function is not absolute, but that, according to the nature of the plants, it passes to potash or to phosphate; in this case nitrogenous matter descends to a subordinate rank. Potash is the dominant of peas, lucern, clover, and the vine. Phosphate is the dominant of the sugar-cane, of sorghum, of maize, and of turnips.

To repeat, we call the dominant of the plant that constituent of the manure which affects by preference the quantity of the crop.

Wheat, colza, beet-root have as their dominant nitrogenous matter.

Vines, peas, lucern, and clover require potash.

Sugar-cane, sorghum, maize, and turnips require phosphates.

If we examine in detail the elements of this table, the importance of the part played, predominating or subordinate, by the three substances, nitrogen, phosphoric acid, and potash, will appear in its striking truth.

Manure	Colza	Wheat	Beets	Potatoes	Sugar-cane	Peas
	Kilos.	Kilos.	Kilos.	Kilos.	Kilos.	Kilos.
Complete	10,400	9,570	50,000	27,950	57,000	6,890
Without lime	8,200	8,200	47,000	20,500	50,000	6,520
— phosphate	7,250	7,563	42,000	16,000	15,000	5,360
— potash	5,550	7,529	37,000	10,500	35,000	4,760
— nitrogen	6,000	4,317	36,000	20,850	56,000	6,335
Land unmanured	1,240	3,542	2,300	7,500	8,000	2,920

The above crops yielded in grain, per hectare and in hectolitres :

——	Colza	Wheat	Peas
Complete manure	39	39	37
Without lime	27	37	37
— phosphate	30	24	30
— potash	16	28	19
— nitrogen	15	13	36
Land unmanured	2	11	19

CATALOGUE OF THE DOMINANTS

Plants	Dominant	Corresponding chemical products
Wheat Colza Barley Oats Rye Natural meadows Beets Hemp	Nitrogen	Sulphate of ammonia Soda-saltpetre Potash-saltpe

CATALOGUE OF THE DOMINANTS—*continued*

Plants	Dominants	Corresponding chemical products
Peas Haricots French beans Clover Sainfoin Vetches Lucern Flax Potatoes Vines	Potash	Potash-saltpetre Potassium carbonate — silicate
Buck wheat Turnips Swedes Maize Sugar-cane Sorghum Rape-seed Artichokes	Phosphoric acid	Phosphates

MANURES

The Chemical Products which enter into the Composition of Manures

§ 1. Chemical manures are adapted to all the necessities of agricultural practice, and may be employed either alone or associated with dung.

§ 2. When alone they have always the advantage over dung, as they weigh twenty times less and contain nothing useless. Their composition may be varied at will, keeping them always in harmony with the especial requirements of each kind of plant, which cannot be done with dung.

§ 3. If stored in a dry place, chemical manures may be preserved indefinitely without injury.

§ 4. The preparation of chemical manures presents no difficulty. A simple shed, the floor of which is well beaten down, is sufficient. The superphosphate is first spread upon the floor in layers of ten centimetres in thickness, and immediately above it the plaster (gypsum), to absorb the moisture of the superphosphate. The whole is well mixed with the shovel and spread out again in a layer of ten centimetres in thickness. The other salts are then spread upon the surface of this first mixture, the whole is again mixed with the shovel, when the process is complete.

§ 5. In large establishments it is preferable to effect the mixture by means of a special machine, excellent types of which are to be met with in trade, capable of being worked by a horse.

§ 6. *Spreading.*—Chemical manures are spread either by hand or by machines. In spreading by hand they are scattered like seed; the machines work like sowing machines.

§ 7. The chemical products which enter into the composition of manures are seven or eight in number—i.e. superphosphate, precipitated phosphate, sulphate of ammonia, soda-saltpetre, potash-saltpetre, potassium chloride, potassium sulphate, and gypsum.

We will say a few words on each of these substances.

Sources of Phosphoric Acid.—The Phosphates

All manurial phosphates are composed of phosphoric acid and lime.

Phosphoric acid itself is formed of phosphorus and oxygen:

Phosphorus	31
Oxygen	40
	71

In the phosphates the phosphoric acid is the active portion. Chemists represent it by this symbol, PO_5.

But, taking PO_5 as a constant term, we have three sorts of phosphates of lime, which are thus represented :

Natural Phosphates

$$PO_5 \quad . \quad . \quad . \quad . \quad . \left\{\begin{matrix} CaO \\ CaO \\ CaO \end{matrix}\right.$$

All natural phosphates have generally this composition :

One equivalent of phosphoric acid,
Three equivalents of lime;

but they are mixed with foreign matter.

When this phosphate is prepared industrially, it consists in the dry state of:

Phosphoric acid	45·81
Lime	54·19
	100·00

In the state in which it is sold, it contains variable and large proportions of water, and is called tricalcic phosphate.

Precipitated Phosphate

$$PO_5 \quad . \quad . \quad . \quad . \quad . \left\{\begin{matrix} CaO \\ CaO + aq. \\ HO \end{matrix}\right.$$

This phosphate, prepared industrially, is more generally known under the name of precipitated phosphate or dicalcic phosphate.

Its composition is:

Phosphoric acid	52·20
Lime	41·18
Water	6·62
	100·00

In the state in which it occurs in trade, it does not contain more than from 32 to 34 per cent. of phosphoric acid, together with an excess of calcium carbonate and of moisture.

Superphosphate

$$PO_5 \; . \quad . \quad . \quad . \left\{\begin{matrix} CaO \\ HO \\ HO \end{matrix}\right. + \text{aq. (?)}$$

This phosphate, known as superphosphate of lime, is never used in a state of purity.

Its composition is then:

Phosphoric acid	60·68
Lime	23·93
Water	15·39
	100·00

In the state in which it is sold it contains from 12 to 30 per cent. of phosphoric acid. It is mixed with gypsum and sand, and contains moisture.

Sources of Nitrogen.—Sodium Nitrate (Soda-Saltpetre)

This salt is formed of nitric acid and soda; its composition is:

Nitric acid	63·53
Soda	36·47
	100·00

The nitric acid itself consists of:

Nitrogen	14·00
Oxygen	40·00
	54·00

Pure nitrate of soda contains 16·4 per cent. of nitrogen, but that of commerce contains seldom more than 15 per cent.

Nitrate of soda is obtained from Peru, where it exists in compact conglomerates mixed with sand and common salt.

Sulphate of Ammonia (*Ammonium Sulphate*)

This salt is formed of sulphuric acid and ammonia:

Sulphuric acid	60·60
Ammonia	25·76
Water	13·64
	100·00

But ammonia in turn is formed of:

Nitrogen	14·00
Hydrogen	3·00
	17·00

It results that sulphate of ammonia, when chemically pure, contains 21·21 per cent. of nitrogen.

That of commerce contains from 20 to 20·5 of nitrogen.

Sources of Nitrogen and Potash.—Potassium Nitrate, Nitrate of Potassa, Potash-Saltpetre

This salt, often known simply as nitre, is composed of nitric acid and potassa.

By its acid it acts as a source of nitrogen, and by its base as a source of potash.

We will first view it merely as a source of nitrogen.

Its composition is:

Nitric acid	53·41
Potassa	46·59
	100·00

As nitric acid is composed of fourteen parts nitrogen in fifty-four parts of nitric acid, potash-saltpetre when pure contains 13·8 per cent. of nitrogen. That of commerce does not contain more than 12 to 13 per cent. Formerly it was obtained by allowing animal matter, mixed with argillo-calcareous soils, to decompose in sheds. At present it is obtained by the mutual decomposition of potassium chloride and sodium nitrate.

We consider next potassium nitrate, not as a source of nitrogen, but as a source of potassa; when pure it contains 46·59 per cent., but in its commercial state it contains about 45 per cent.

Potassium Chloride

Potassium chloride is obtained from the mother-liquors of salt marshes, or from the deposits of the double potassium and magnesium chloride which sometimes accompany rock-salt.

Potassium chloride has the composition:

Potassium	52·41
Chlorine	47·59
	100·00

The corresponding proportion of potassa is 63·14, but the commercial chloride at 80 per cent., which is the current strength, contains the equivalent of 50 per cent. of potassa.

Sources of Lime.—Plaster

Gypsum or calcium sulphate is formed of sulphuric acid and of lime.

Sulphuric acid	46·51
Lime	32·56
Water	20·93
	100·00

If exposed to a temperature of 120° C. it loses its water, and is then known as plaster, the form in which I recommend it to be used by preference.

Cost of Chemical Manures compared to that of Dung

§ 1. Dung costs on an average fifteen francs per ton.

§ 2. In a ton of farmyard dung there are—

	Kilos.			Kilos.
Nitrogen	4	In 40,000 kilos.	Nitrogen	160
Phosphoric acid	2		PO_5	80
Potash	4		KO	160
Lime	8		Lime	320

§ 3. We obtain the equivalent of 40,000 kilos. of dung in chemical manures by using:

	Kilos.		Francs		Kilos.		Francs
Superphosphate .	600	at	12	per	100	=	72
Potassium chloride at 80 per cent.	320	,,	18	,,	,,	=	57
Ammonium sulphate	785	,,	35	,,	,,	=	274
Gypsum . .	600	,,	2	,,	,,	=	12
Weight . .	2,305		Cost		.	.	415

§ 4. Say ten francs to have in chemical manures the equivalent of a ton of dung, the cost price of which is at least fifteen francs.

§ 5. Since 1867 the price of chemical manures has undergone several fluctuations; at first a continuous rise, then a time of quiet, and lastly a decline, due to the creation of homologous manures, which brought potassium chloride into use, and to the great increase in the production of sulphate of ammonia.

§ 6. Chemical manures are more efficacious than dung. They weigh twenty times less, and are cheaper. We may add that their action is more durable. This is proved by numerous experiments, among others those of M. Peyrat, at present Inspector of Agriculture at the farm of Beyrie in the Landes.

Catalogue and Composition of the Principal Manures of M. Georges Ville

Percentage in fertilising agents			Per cent.	Per hectare
Complete Manure, No. 1.—For Colza, Hemp, Wheat, Barley, Oats, Rye, Pasture. 600 *to* 1,200 *kilos. per hectare*				
				Kilos.
N .	6·5	Superphosphate	33·34	400
PO_5	5·00	Nitrate of potash	16·66	200
KO .	8·00	Sulphate of ammonia . . .	20·83	250
CaO	17·00	Gypsum	29·17	350
			100·00	1,200

Percentage in fertilising agents			Per cent.	Per hectare
Homologous Manure, No. 1′.—For the same use and in the same proportions				
				Kilos.
N	6·6	Superphosphate	33·34	400
PO_5	5·00	Potassium chloride (80 per cent.)	16·66	200
KO	8·33	Sulphate of ammonia	32·50	390
CaO	13·0	Gypsum	17·50	210
			100·00	1,200
Complete Manure, No. 2.—Cabbage, Beets, Carrots, Garden use in general				
N	6·5	Superphosphate	33·34	400
PO_5	5·00	Nitrate of potash	16·66	200
KO	8·00	Nitrate of soda	25·00	300
CaO	15·00	Gypsum	25·00	300
			100·00	1,200
Homologous Manure, No. 2′.—For the same crops and in the same proportions				
N	6·5	Superphosphate	33·34	400
PO_5	5·00	Potassium chloride (80 per cent.)	16·66	200
KO	8·33	Sulphate ammonia	11·66	140
CaO	14·00	Nitrate of soda	25·00	300
		Gypsum	13·34	160
			100·00	1,200
Complete Manure, No. 3.—Potatoes, Tobacco, Flax, Vines				
N	4·0	Superphosphate	40·00	400
PO_5	6·0	Potash-saltpetre	30·00	300
KO	14·0	Gypsum	30·00	300
CaO	19·0			
			100·00	1,000

Percentage in fertilising agents		Per cent.	Per hectare
Complete Manure, No. 4.—Vines, Tobacco, Fruit-trees, Ornamental Plants			
N . 4·6	Superphosphate	40·00	600
PO_5 6·0	Potash-saltpetre	33·34	500
KO . 15·5	Gypsum	26·66	400
CaO 17·0			
		100·00	1,500
Complete Manure, No. 5.—For Maize, Artichokes, Sorghum, Rape-seed, Sugar-cane			
N . 2·5	Superphosphate	50·00	600
PO_5 7·5	Potash-saltpetre	16·66	200
KO . 8·0	Gypsum	33·34	400
CaO 22·0			
		100·00	1,200
Complete Manure, No. 6.—For Fine Flax, Leguminous Plants, and Lucern			
N . 2·7	Superphosphate	40·00	400
PO_5 6·0	Potash-saltpetre	20·00	200
KO . 9·0	Gypsum	40·00	400
CaO 22·0			
		100·00	1,000
Incomplete Manure, No. 1 (without Potash).—For Colza, Cereals, Pasture			
N . 7·0	Superphosphate	40·00	400
PO_5 6·0	Ammonium sulphate	35·00	350
KO . 0·0	Gypsum	25·00	250
CaO 17·0			
		100·00	1,000
Incomplete Manure, No. 6 (without Nitrogen).—For Clover, Sainfoin, Lucern, Leguminous Crops			
N . 0·00	Superphosphate	40·00	400
PO_5 6·00	Potassium chloride (80 per cent.)	20·00	200
KO . 10·0	Gypsum	40·00	400
CaO 22·0			
		100·00	1,000

The use of Chemical Manures when employed alone

§ 1. The rule is to let the manures alternate in accordance with the rotation of crops.

§ 2. Biennial rotations, comprising:

MAIZE—WHEAT

		Kilos.
1st *year* Maize	Manure No. 5	1,200
	Say:	
	Superphosphate	600
	Potash-saltpetre	200
	Gypsum	400
2nd *year* Wheat,	Ammonium sulphate	300

§ 3. Rotation for four years, including

POTATOES, WHEAT, CLOVER, WHEAT

		Kilos.
1st *year* Potatoes	Complete manure, No. 3	1,000
2nd *year* Wheat	Ammonium sulphate	300
3rd *year* Clover	Incomplete manure, No. 6	1,000
4th *year* Wheat	Ammonium sulphate	300

Chemical Manures associated with Dung

§ 4. If in the course of the rotation the quantity of dung employed is 5,000 kilos. yearly per hectare, it must be considered as an increase of fertility accruing to the earth, and the dose of chemical manures prescribed when employed alone must not be changed.

§ 5. If the quantity of dung employed amounts to 10,000 kilos. yearly, the dose of chemical manures must be reduced to one-half during the two first years returning afterwards to the full doses.

§ 6. Four years' rotation, comprising

POTATOES, WHEAT, CLOVER, WHEAT

		Kilos.
1st year, Potatoe	Farmyard dung	40,000
	Complete manure, No. 3	500
	Say:	
	Superphosphate	200
	Potash-saltpetre	150
	Gypsum	150
2nd year, Wheat	In autumn	Nothing
	In spring, if the wheat is fine	Nothing
	If poor and backward, ammonium sulphate as a top dressing	100–150
3rd year, Clover	Incomplete manure, No. 6	1,000
	Say:	
	Superphosphate	400
	Potassium chloride	200
	Gypsum	400
4th year, Wheat	In autumn	Nothing
	In spring, if wheat is fine	Nothing
	If poor or backward, ammonium sulphate	100–200

Results obtained in the Experimental Field at Vincennes.—Colza, 1874

Experience has convinced me that it is preferable to apply the nitrogenous manure in two doses.

If the whole is given at once in autumn the plant throws out enormous leaves, but at the first frosts these leaves fall off, and the nitrogen which they contain is only in part returned to the soil.

With a smaller dose of nitrogenous manure given in autumn the plant takes a smaller growth, but its activity is increased by an additional dose in spring.

	Yield per hectare. Hectolitres
Complete manure, No. 1 (nitrogenous matter in two doses)	39
Ditto, in one dose	27
Manure without nitrogen	15
„ „ phosphate	20
„ „ potash	16
„ „ lime	17
No manure	2

Effects Produced on Colza, in 1877, by Progressive Doses of Nitrogen

	Hectols. per hectare
1. Complete manure with 100 kilos. nitrogen	50
2. „ „ 80 „	32
3. „ „ 60 „	34
Without any manure	15

Crop	Complete manure		Mineral manure		No manure	
	Kilos.	Hecs.	Kilos.	Hecs.	Kilos.	Hecs.
1864	11,490	41	9,300	28	7,920	25
1865	6,250	21	2,510	6	1,690	4
1866	14,490	45	9,150	22	6,750	19
1867	11,560	30	7,700	18	5,760	16
1868	7,650	25	6,130	15	2,090	7
1870	5,940	18	2,970	7	1,970	7
1872	15,800	45	13,850	38	10,100	28
1873	15,000	46	9,050	30	1,800	4
1874	10,500	39	6,000	15	1,240	2
Mean	10,964	34	7,406	20	4,368	12

THIRD LECTURE

This has been devoted to the study of the chief causes of loss and failure—a sad but an unavoidable subject—and to the exposition of the principles upon which sideral rotations are founded.

I have referred the sources of loss to four main causes, exclusive of those derived from commercial considerations.

These four causes are:

1. The insufficiency of manure.
2. Insufficient preparation of the soil, and consequent spread of weeds.
3. Exclusive use of dung produced on the farm.
4. Bad management.

To these four causes there might be added a fifth, the expiry of the period at the end of which the working capital must be recovered.

If you produce only vegetable crops, the capital should be turned over as rapidly as possible; but if you are a producer of animals, it may be your interest to let the stock grow, as it gains weight every day, and the realisation may be deferred. I do not possess data for laying down in this matter rules of which I have a glimpse, although I am not yet able to state them with precision.

After having pointed out the causes of failure, I have felt bound to indicate the means of avoiding them. These means, especially destined for the assistance of proprietors condemned to cultivate in spite of themselves, may be summed up in two words: Sideral rotation.

It will not be useless if I define once more what I call sideration and sideral rotations.

SIDERATION

The sun in the course of a year pours upon the surface of a hectare of land the equivalent of 2,000,000 days' work of one steam horse-power, whilst the cultivation of the land does not utilise more than 8,000.

I have sought to make use of a portion of this excess of force to reduce the cost of cultivation, to manure the land cheaply, or to increase the product of the crop.

I call sideration the procedures which enable us to reach these three objects, separately or conjointly.

We attain this object—

1. By cultivating among the cereals a second plant which chokes the weeds and reduces the cost of labour. *This is the sideration of counteraction.*

Red clover sown among corn in the first place chokes the weeds. Instead of being obliged to give a first ploughing to remove the stubble, and then a deep ploughing, the former of these operations, thanks to the clover, may be dispensed with, thus effecting an economy of at least 60 francs per hectare.

2. By the cultivation of clover in place of dead fallow with the incomplete manure, No. 6 (composed of phosphate, potash, and gypsum, without nitrogenous matter). This clover when ploughed in converts the incomplete manure, No. 6, into the complete manure, No. 1, which is the especial manure for cereals. This is the *sideration of fertilisation*, which, in fact, converts the fallow into a manure-pit.

3. By the cultivation among the cereals of a forage-plant with a dominant of nitrogen, which adds to the straw a crop of forage without injuring the production of grain.

This is the *forage sideration*, which also acts as a *sideration of counteraction.*

All these effects have not received the consecration of sufficient experience. They are theoretical deductions, rather than practical facts already recognised.

Ten years ago I should not have consented to publish them. But now I ought not to wait any longer. The situation in which the agriculture of Western Europe is placed by foreign competition is too serious. It has not seemed to me permissible to sacrifice general interests to private views.

Moreover, in what shall I be discredited when practice shall have brought these propositions into a better equilibrium than I can do myself, even admitting that I may be corrected in some points, if a progress, a great progress, survives my attempt? And progress enjoins it upon us to take nitrogen directly from the air, and to derive the minerals, phosphate, potash, lime, from a permanent importation of chemical manures.

As an example of this method I originally proposed to dig in the first cutting of clover; then I thought of burying two cuttings. Lastly, it may be found more advantageous in practice to feed off the first growth on the spot and to bury merely the second.

A meadow pasturage, supported by the cultivation of clover, will accelerate the fattening of stock in a considerable proportion. All variations in the application make no change in the principle. They are, on the contrary, a more generalised affirmation, but on one condition—that none of the clover is sold away.

I cannot lay down my pen without announcing a great advance in the application of the sideral methods. I will call this advance *superimposed sideration.*

M. Gaudet has had the happy thought of sowing lupines immediately after the clover has been ploughed in; this second sideration must present great advantages for spring cultivation.

		Manure per hectare. Kilos.		
The same year	Sideral clover .	1,000	incomplete manure,	No. 6
	Sideral lupines after clover	500	”	”

By this double sideration the cleansing of the soil from weeds will be carried to its utmost limit, and the mass of nitrogen accumulated in the earth is truly enormous.

I am about to make the experiment this year, and what I have said is merely for the sake of claiming priority on its behalf.

Nitrogenous Sideration

This method has been proposed by M. Berthelot.

Certain plants, borage and the Amarantaceæ, have the power of producing nitre from the nitrogen of the air. According to the ‘Gazette des Campagnes’ (May 16, 1885), M. Berthelot proposes the sideration of these plants; which is justifiable, since they yield to the soil nitrogen at once in the state of nitre (potassium nitrate) and as organic matter.

One point remains to be decided: Is the cultivation of these plants, like that of clover, possible in the place of a fallow to facilitate the preparation of the land? If this point is decided in the affirmative, nitrogenous sideration will take a most useful and well-defined position in agricultural practice.

But whatever form of sideration is concerned—the sideration of fertilisation, superimposed, or nitrogenous sideration—they are all a deduction from the fundamental fact that certain plants derive their nitrogen directly from the atmosphere, and that—e.g. contrary to wheat and colza—they derive no appreciable benefit from nitrogenous manures.

In the following pages I have collected numerous instances of plants upon which nitrogenous manures have an unfavourable action, those to which they are absolutely neutral or inert, those upon which they act a little, and those upon which they act much.

First Case.—Nitrogenous manures exert a distinctly unfavourable action.

CLOVER

—	Yield per hectare	
	Complete manure with nitrogen	Mineral manure without nitrogen
	Kilos.	Kilos.
1849	9,550	9,625
1850	2,406	2,352
1851	3,611	5,372
Annual mean	5,189	5,783

On August 28, 1884, at 5 P.M. I returned from the experimental field of Vincennes filled with a sentiment of unutterable satisfaction.

In the spring I caused red clover to be sown in all the squares of a plot of wheat. The wheat was reaped three weeks ago, but this is what I want to put on record. The first and most abundant clover is that of No. 6, which since the establishment of the experimental field, twenty-four years ago, has received merely mineral manures without nitrogenous matter. This plot is incomparably superior to the plots which have received the complete manure. In the plots which have received only nitrogenous matter without minerals the clover is detestable, and it will not survive the cold of the winter.

On the plot which has received the complete manure *without potash* it is also very bad, and on the plots without any manure there is nothing.

These results have for me nothing novel or unexpected, since by reason of their great number and the conditions under which they have been produced they furnish the most striking confirmation of the first researches of my youth, and of those whose truth is still obstinately contested, but which in the full maturity of my life I see destined to become the safety-raft of distressed agriculture. Here is justice done by science against the ingratitude of man.

Second Case.—Plants towards which nitrogenous manures are absolutely indifferent: lucern and peas.

LUCERN AT THE EXPERIMENTAL FIELD OF VINCENNES

—	Yield per hectare	
	Manure with nitrogen	Manure without nitrogen
1868	13,772	13,185
1869	11,603	11,743
1870 (partial) . . .	5,249	8,166
1872	3,110	2,585
1873	6,597	8,161
1874	9,410	9,860
1875	8,099	10,132
	57,840	63,832
Yearly mean . . .	8,263	9,119

Peas

—	—	Complete manure		Mineral manure		No manure	
		Kilos.	Hectols.	Kilos.	Hectols.	Kilos.	Hectols.
1862	Straw .	3,930	22	3,680	26	2,470	18
	Grain .	1,690		2,010		1,470	
		5,620		5,690		3,940	
1863	Straw .	2,180	9	2,660	10	1,340	5
	Grain .	700		810		390	
		2,880		3,470		1,730	
1864	Straw .	3,000	17	3,020	21	2,110	10
	Grain .	1,370		1,620		820	
		4,370		4,040		2,930	

Haricot Beans

—	—	Complete manure		Mineral manure		No manure	
		Kilos.	Hectols.	Kilos.	Hectols.	Kilos.	Hectols.
1865	Straw .	2,100	23	1,930	26	1,210	9
	Seed . .	1,820		2,030		720	
		3,920		3,960		1,930	
1867	Straw .	3,820	32	3,525	37	2,440	19
	Seed . .	3,070		2,810		1,480	
		6,890		6,335		3,920	
1868	Straw .	3,025	22	2,300	17	1,760	13
	Seed . .	1,720		1,250		1,040	
		4,745		3,550		2,800	
1869	Straw .	4,970	30	4,030	27	2,670	17
	Seed . .	2,450		2,100		1,300	
		7,420		6,130		3,970	
1870	Straw .	1,570	13	2,070	16	635	5
	Seed . .	1,010		1,310		400	
		2,580		3,380		1,035	

HARICOT BEANS—*continued*

—	—	Complete manure		Mineral manure		No manure	
		Kilos.	Hectols.	Kilos.	Hectols.	Kilos.	Hectols
1872	Straw .	3,020	24	3,050	26	1,450	10
	Seed . .	1,990		2,151		850	
		5,010		5,201		2,300	
1873	Straw .	3,400	31	3,500	35	2,050	12
	Seed . .	2,600		2,800		1,000	
		6,000		6,300		3,050	
General Mean							
Total crop . .		4,943 kilos.		4,866 kilos.		2,760 kilos.	
Seed . . .		22 hect.		24 hect.		12 hect.	

Third Case.—Plants upon which nitrogenous manures have a slight action: the potato and the sugar-cane.

POTATOES, 1867

	Tubers per hectare Kilos.
Complete manure without nitrogen . .	20,850
„ „ with 28 kilos. nitrogen .	20,700
„ „ „ 44 „ „ .	21,900
„ „ „ 76 „ „ .	24,600

POTATOES

	Crop per hectare. With 117 kilos. nitrogen	Crop per hectare. With 76 kilos. nitrogen
Complete manure	27,950	24,600
„ „ without lime .	23,350	20,500
„ „ „ phosphate	17,900	20,500
„ „ „ nitrogen .	16,750	20,850
„ „ „ potash .	7,700	7,500

In the absence of potash the nitrogen is rendered inactive.

	Kilos. per hectare	
	Kilos.	Kilos.
Complete manure, 117 kilos. nitrogen	27,950; without KO	10,520
„ „ 76 „ „	24,600 „ „	10,500

Remark the contrast between the effects produced by the omission of nitrogen and of potash. The suppression of nitrogen has no very marked effects; the effects of the suppression of potash are enormous.

POTATOES, FROM 1865 TO 1873

Crop	Complete manure	Manure without nitrogen	Manure without potash	No manure
	Kilos.	Kilos.	Kilos.	Kilos.
1865	27,950	16,750	10,520	7,700
1867	24,600	20,850	10,000	7,650
1868	24,300	20,400	8,800	4,750
1869	16,000	12,600	7,650	3,860
1870	12,700	13,000	6,100	1,900
1871	18,800	15,000	5,700	4,760
1872	16,000	7,100	7,000	4,950
1873	14,000	10,800	7,500	4,000
General mean	19,290	14,660	7,900	4,940

SUGAR-CANE, 1867

The nitrogen in manures acts little. Phosphate acts much.

	Canes per hectare, stripped of leaves. Kilos.
Complete manure, 28 kilos. nitrogen	74,000
„ 45 „	79,732
„ 60 „	86,840
„ 90 „	87,267

Fourth Case.—Plants where the nitrogenous matter regulates the quantity of the crop—e.g. wheat.

Crop	—	Complete manure		Mineral manure		No manure	
		Kilos.	Hectols.	Kilos.	Hectols.	Kilos.	Hectols.
1861	Straw	4,250	30	4,120	27	2,270	21
	Grain	2,400		2,130		1,705	
		6,650		6,250		3,975	
1862	Straw	3,930	24	3,950	19	3,270	14
	Grain	1,900		1,520		1,080	
		5,830		5,470		4,350	
1863	Straw	6,960	47	4,004	17	4,740	15
	Grain	3,750		1,287		1,266	
		10,710		5,291		6,006	
1864	Straw	4,500	24	2,300	13	1,220	5
	Grain	1,890		1,060		360	
		6,390		3,360		1,580	
1865	Straw	4,030	35	2,253	16	1,950	11
	Grain	2,520		1,247		870	
		6,550		3,500		2,820	
1866	Straw	8,750	36	2,220	9·6	720	3
	Grain	2,860		720		260	
		11,610		2,940		980	
1867	Straw	8,440	29	3,032	12	1,670	7
	Grain	2,235		962		540	
		10,675		3,994		2,210	
1868	Straw	5,840	39	2,310	20	1,480	10
	Grain	3,100		1,600		760	
		8,940		3,910		2,240	
1869	Straw	4,750	25	2,278	11	1,252	6
	Grain	1,750		813		447	
		6,500		3,091		1.699	

Crop	—	Complete manure		Mineral manure		No manure	
		Kilos.	Hectols.	Kilos.	Hectols.	Kilos.	Hectols.
1870	Straw .	7,554	43	2,082	7	2,690	7·5
	Grain .	3,396		528		600	
		10,950		2,610		3,290	
General Mean.							
Total crop . .		8,478 kilos.		4,041 kilos.		2,915 kilos.	
Grain . . .		33 hect.		15 hect.		10 hect.	

Colza, hemp, and beets, like wheat, belong to the plants which have nitrogen as their dominant, and they consequently, like wheat, require large quantities of nitrogen in manure.

Conclusions

It is, therefore, demonstrated by the foregoing facts that there exists among plants a striking contrast with respect to the action of nitrogenous manures.

Upon clover their action is hurtful; towards peas and lucern they are inert; to potatoes they are slightly useful; and in case of wheat, beet, and colza their effect is unrivalled, as they regulate the yield of the crop.

SIDERATION

Since these theoretic notions have appeared, experiments have been made in great numbers by Signor Visocchi in Italy, M. Gaudet and Baron d'Avène in France, and by myself at the experimental field at Vincennes. We may say that the practical application of sideration is fixed as to its fundamental data.

The right of precedence belongs in the order of time to Signor Visocchi; M. Gaudet and the Baron d'Avène come after him.

I will take up the word lastly, in order to give more generality to their conclusions, and more force and precision to their terms.

The reader will see novel expressions figuring here for the first time, and it is necessary to come to a decision as to their bearing and their signification.

Sideration produces a variety of effects, which may be arranged under three principal heads:

1. Sideration of Concentration and Repulsion.

2. Sideration of Fertilisation, which is again subdivided into Simple and Double Sideration.

The Sideration of Concentration permits us to employ enormous doses of manure without having to fear accidents, such as the 'laying' of corn. For this purpose it is sufficient to sow a plant—among others buckwheat—before the cereals. Buckwheat fixes a part of the manure, which it will restore to the soil on its decomposition, and moderates its too abruptly energetic action.

A sowing of beets or of flax is defective; it is better to sow buckwheat and plough it in two months afterwards than to leave the earth bare: this is what I call the Sideration of Concentration. But the buckwheat produces a second useful effect; it chokes the weeds, and in this manner produces an effect comparable to a harrowing, though founded on a different mode of action. Hence the expression—Sideration of Concentration and of Repulsion.

3. Lastly, the Sideration of Fertilisation, the purpose of which is the copious manuring of the soil, and which is

divided into two categories: Simple and Double Sideration. This distinction needs no commentary; it is justified by its mere announcement.

We have simple sideration when we plough in a single cutting of clover or the produce of a single crop. We have double sideration when we plough in two cuttings of clover, or if we cause a second crop to follow upon the first cutting of clover.

In this respect there is still a distinction to be made —having recourse to a second leguminous crop, or substituting for it a plant with a dominant of nitrogen, giving a nitrogenous manure.

As instances we may have simple sideration with leguminous plants, the first cutting of clover being ploughed in and followed by a crop of lupines.

Or we may have double sideration by means of a plant with a dominant of nitrogen, burying the first cutting of clover, followed by a mixed crop of buckwheat and mustard, to which are given 200 kilos. of ammonium sulphate.

These various methods of working explain themselves, and all tend to the same ends: to choke the weeds, to manure the soil by a supply of mineral matter, phosphates, potash, and lime, and nitrogen drawn from the air.

I now give place to my eminent collaborators.

THE RESULTS OF SIGNOR VISOCCHI. THIRTEEN YEARS OF SIDERATION. IMPROVEMENT OF THE SOIL BY MEANS OF LEGUMINOUS PLANTS

From the 'Journal d'Agriculture pratique' (December 31, 1885, p. 947):—

A long time ago, recognising as true *the theory of* *the fixation of atmospheric nitrogen by means of leguminous plants*, I thought that by means of the cultivation of these plants we might diminish the expense of manures, and reduce them to the cost of the mineral inorganic fertilisers, of the seed, and the cultivation of a leguminous plant to be dug in.

Following up this idea, and to arrive at a decision as to its real practical value, in October 1872 I began to apply it to the cultivation of a small field. I have since continued this cultivation year by year on the same land and with the same method of manuring. On reaching the thirteenth year, by reason of the attention and interest which the sideral cultivation proposed by M. Georges Ville was exciting among farmers, I thought that it might not be useless to publish the results of my experience.

I established my experimental field in a district capable of being watered, which in former years had been under a rotation of wheat and maize, and which had received every other year a dressing of about 300 quintals of farmyard manure. When I began my experiment it was at the end of the rotation, when it would have been necessary to manure again.

The land was divided into two plots, one of which was sown with wheat and the other with maize, so as to continue the old rotation. Every year, in fact, maize followed on the plot which had been sown with wheat the year before. Each plot received yearly, instead of farmyard manure, superphosphate or precipitated phosphate, potassium chloride or wood-ashes not lixiviated, and the digging in of a leguminous plant which has been cultivated between reaping the wheat and sowing the maize. The quantity of superphosphate or precipitated phosphate spread on each plot biennially corresponds to 96 kilos. of phosphoric acid per hectare, and the quantity of potassium chloride or wood-ashes to 90 kilos. of potash per hectare. The leguminous plant to be dug in has been almost always sown in the wheat, and has been either clover, or *Galega officinalis*, or *Hedysarum*, sometimes merely small beans sown in autumn on the wheat-stubble. All these leguminous plants were buried after the time of blossoming towards the end of April, immediately before sowing the maize.

From the experimental field, divided into two parts, there have been obtained during the thirteen years thirteen crops of wheat and as many of maize. The mean annual yield per hectare has been—

	Hectolitres
Wheat	26½
Maize	70

As it is seen, the crop of wheat is not very high; but the maize, perhaps as having been the first to profit by the buried vegetation, and because it could be irrigated in case of need, has given a very satisfactory return. If we throw together the produce of the two crops—i.e. 26½ hectols. of wheat and 70 hectols. of maize—we have for the sum of the two crops 96½ hectols., and consequently 48¼ hectols. as the total annual crop.

But since the money value of maize is less by one-third than that of wheat, the 70 hectols. of maize are worth as much as 46 hectols. of wheat, and the sum of the two crops in wheat, or in the equivalents of wheat, is worth in money 72½ hectols.—i.e. 36¼ hectols. of wheat or its equivalent yearly and per hectare.

The cost of manuring to obtain this product has been biennially per hectare:

	Francs
Seed and sowing	36
Extra labour for digging in	14
Phosphoric acid (96 kilos. at 1 franc)	96
Potash (90 kilos. at 0·60 franc)	54
Total for 2 years	200
Yearly per hectare	100

With such results I believe that, by burying leguminous plants, we may enrich the soil with the nitrogen which the plants by what means soever draw from the atmosphere. In consequence we can in many cases diminish the cost of manuring by suppressing the nitrogen, which alone costs more than all the other agents of fertility taken together.

Certainly I was wrong when beginning my trials not to have left alongside the trial-lands a small field cultivated without any manure. The comparison of the products would have given a proof much more decisive. But I believe no one can doubt that the nitrogen of the thirteen successive crops of cereals obtained on the experimental field must have come from the buried leguminous plants. It might have been possible to doubt for a first or a second crop, but for a twelfth or a thirteenth it seems out of the question.

As for myself I have no doubt, because I have seen that the crops of the last years have been like those of the first, and that the rest of the land in which the experimental field is situate has always required to be dressed with farmyard manure in order to give a production not inferior to that of the experimental field.

THE CULTIVATIONS OF M. GAUDET

The rotation practised by an eminent agriculturist, M. Gaudet, near Montrond, in the Department of the Loire, is the following:—

1st	*year.*—Fallow, with a double ploughing-in of legumens, clover, and lupines.	
2nd	„	Potatoes.
3rd	„	Wheat.
4th	„	Potatoes.
5th	„	Oats, with clover sown for the sideral fallow

M. Gaudet adds:

I obtain by this method very good results, 30 to 40 hectols. of wheat per hectare, and from 20 to 30,000 kilos. of potatoes, in place of 8 to 10,000 which is the average of the country. [M. Gaudet works lands letting at 25 francs per hectare.]

You will remark that the possibility of cultivating two leguminous plants, the crops of which are superimposed upon each other, facilitates the application of sideration to alternating and to triennial rotations, and compensates in temperate regions the disadvantage which they sustain in comparison with tropical countries, where simple sideration may be obtained without leaving the land fallow for a year.

I perceive here the starting-point of processes of a power hitherto unknown from the threefold point of view of the extinction of weeds, the concentration of the manure, and the fertilisation of the soil.

CONCLUSIONS OF A REPORT OF THE VICOMTE D'AVÈNE, A PROPRIETARY FARMER OF SEINE-ET-MARNE

Without question the most rational and the best practice is indisputably that which gives *certain* results, consists in burying the first cutting of red or violet clover as soon as it enters into full flower.

There is thus time to cleanse the earth from weeds by treatment with the scarifier, and to give a second ploughing early, so that the soil may be in good condition at the time of sowing the wheat.

With the sideral rotation the expense of labour is much lower, the produce higher and more certain, than by any other method of cultivation ; the sideral manure is richer in nitrogen and yields to the soil a notable quantity of humus, so useful for good vegetation.

Sideral cultivation should therefore be regarded as a new and very important step in the way of progress.

Sideration of Concentration

In 1887 I caused to be sown in the experimental field of Vincennes sugar-beets in twelve plots. In consequence of the dry weather the seed failed completely.

At Vincennes, as the experimental field should render the conclusions of my teachings sensible and intelligible for all, it was not possible to leave twelve plots unoccupied. I decided therefore to sow the twelve lots with buckwheat, with the design of burying the green crop. In acting thus I proposed at once to occupy the earth so as to oppose a barrier against weeds, and to concentrate the chemical manure originally intended for the beets in a green crop easy of decomposition which would occupy the bottom of the furrows. The buckwheat was in my opinion merely a sort of skimmer to collect what was scattered. I made abstraction of the nitrogen which the buckwheat might draw from the air.

What was the result of this attempt, sprung from a fortuitous incident which reflection had rendered fruitful?

An excess of crop of 2,000 kilos. per hectare, in which the grain figured for 10 hectolitres.

The earth had received 1,200 kilos. per hectare of complete manure, No. 2, in which the nitrogen amounted to 75 kilos.—i.e.:

COMPLETE MANURE, No. 2, 1,200 KILOS.

	Per hectare. Kilos.
Superphosphate	400
Potash-saltpetre	200
Soda-saltpetre	300
Gypsum	300
Total	1,200

In one case only the earth had been left bare, and in the other buckwheat had been sown with the intention of ploughing in the crop.

Under these two conditions there was obtained:

—	Produce per hectare	
	Total	Grain in hectolitres
1. With sideration	10,480	44·80
2. Without sideration	8,000	34·80
Difference in favour of sideration	2,000	10·00

Thus, by the mere fact of the concentration of the chemical manure, the crop has been considerably increased; but this is not the only advantage—the wheat has not been laid or scorched.

Along with these two experiments there has been made a third, in which the proportion of nitrogen introduced by chemical manures reached 120 kilos. per hectare by an increase of ammonium sulphate, and the land was also sown with buckwheat, which was ploughed in.

The yield of wheat this time reached 13,130 kilos. per hectare, and the production of grain 53·49 hectols.

In spite of this excessive growth, and of the storms later in the season, the wheat remained upright and firm to maturity, while close at hand seven or eight varieties of wheat, selected as among the best, but which were cultivated with chemical manures without sideration, were all laid and scorched in June.

Certainly where there had been sideration with buckwheat, the wheat grew more slowly. Its increase was more regular and more continuous. The abruptness of a too sudden growth was avoided. The manure having been deposited at the bottom of the furrow the plant took deeper root, and was enabled to resist the wind. Its ripening took place more slowly, and the grain gained more weight.

	Weight per hectolitre. Kilos.
1. With sideration	85
2. Without sideration	83

To bring these facts into higher relief I beg you to consider the totality of the results.

—	Yield per hectare	
	Total	Grain in hectolitres
1. No manure	1,860	7·34
2. Chemical manure, 75 kilos. nitrogen. No sideration	7,900	34·81
3. Chemical manure, 75 kilos. nitrogen, with sideration	10,480	44·82
4. Chemical manure, 120 kilos. nitrogen, with sideration	13,130	53·42

The wheat sown was Australian bearded wheat, and the grain was superb.

Sideration of Fertilisation

Notwithstanding their importance these results are, to tell the truth, merely a stage towards the culminating effect of sideration. The result which we place above all others is produced when the clover acquires its full development, and when the soil gains by its aid a strong dose of nitrogen, which, I repeat, is the peculiarity of the sideration of fertilisation.

But here we stop again and wish you to remark that the two first effects of repulsion and concentration are also obtained by the sideration of fertilisation, forming in a manner the synthesis of the two former. which it complements and renders fruitful.

For the sideration of repulsion, where the clover is buried the first year, we give the earth as a manure 500 kilos. of gypsum per hectare.

For the sideration of fertilisation, on the contrary, when clover takes the place of fallows, and occupies the ground for a full year, there are used 1,000 kilos. of incomplete manure, No. 6—i.e.:

INCOMPLETE MANURE, No. 6. 1,000 KILOS.

	Per hectare. Kilos.
Superphosphate	400
Potassium chloride (80 per cent.) . .	200
Gypsum	400
	1,000

spread in autumn immediately after harvest.

I repeat it, the whole is here simple, the practice and the result, and all enters without innovation into the system of current procedures.

Here, as a first indication, are various results obtained on the experimental field at Vincennes :—

CROP OF 1885, VIOLET CLOVER, SOWN AMONG WHEAT IN 1884

—	Yield per hectare	
	Green	Dry
	Kilos.	Kilos.
1. Mineral manure without nitrogen . .	22,400	6,890
2. Complete manure with 80 kilos. nitrogen	17,600	5,259
3. Complete manure with 120 kilos. nitrogen	19,800	5,980

From another plot, where the clover was the finest of the whole field, the yield per hectare was—

—	Green	Dry
	Kilos.	Kilos.
Clover	51,500	8,500
Roots	8,700	2,000
Total	60,200	10,500

which corresponds to the following quantities of nitrogen:

	Kilos.
Stems	217·260
Roots	43·268
Total nitrogen	260·528

On the large scale there has been obtained to my knowledge in the neighbourhood of Nemours, in 1883, with red clover ;

—	Per hectare		
	Green	Dry	Nitrogen
	Kilos.	Kilos.	Kilos.
Stems . . .	37,500	6,808	198·000
Roots . . .	3,030	692	14·119
	40,530	7,500	212·119

We may see by these last instances that the roots take an important part in the production of the crop. I ask, therefore, that the weight of the roots should be taken into account in the results which will be communicated.

But these effects are far from the limit which may be reached by means of plants which collect nitrogen.

In 1864 I reaped on the experimental field of Vincennes from 14,000 to 15,000 kilos. of lucern per hectare, and I said then: 'If to give more weight to my argument I suppose the crop reduced to 12,000 kilos., I still find that it contains 248 kilos. of nitrogen having its origin in the air.'[1]

'With a yield of 15,000 kilos. the quantity of nitrogen drawn from the atmosphere would exceed 300 kilos. per hectare.'

But the mere isolated crop of clover is not the only effect of fertilisation which it is possible to produce. There is a second much more powerful. In place of producing, as manure, a single crop of leguminous plants, we may obtain two crops in superposition; for instance, a crop of lupines or winter vetches after that of clover. But then the dose of manure must be increased by 50 per cent.

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[1] 1864, *Lectures at Vincennes*, p. 100. In the figures which I give there have been deducted from the crop 90 kilos. of nitrogen which had been contained in the manure. But as mineral manure without nitrogen would have produced as much as complete manure with nitrogen, we may add 400 kilos. yearly per hectare to the quantity of nitrogen which may be obtained from the air by means of three cuttings of lucern,

For clover we continue to give, as before, 1,000 kilos. of incomplete manure, No. 6, per hectare—i.e.:

	Kilos.
Superphosphate	400
Potassium chloride (80 per cent.)	200
Gypsum	400
Total	1,000

For lupines or vetches we give to the land, after having ploughed in the clover, 500 kilos. more of the same incomplete manure, No. 6, per hectare.

If in place of a leguminous plant we sow for the second sideration a plant with a dominant of nitrogen, we must give to this plant a little nitrogenous manure, 100 or 150 kilos. ammonium sulphate per hectare.

The following are the results of these various modes of sideration:—

SIMPLE SIDERATION

	Kilos.
Violet clover siderated, plants and roots	3,6950
Containing nitrogen	142

CROP

Wheat, total crop	10,030
Containing grain	2,734

or 36 hectolitres.

Double Sideration with a Plant having a Dominant of Nitrogen and a Nitrogenous Manure

First Experiment

	Kilos.
1. Violet clover siderated, plants and roots	34,330
Containing nitrogen	220

After the sideration of the violet clover, there are given to the soil 100 kilos. of ammonium sulphate, containing 20 kilos. of nitrogen, and there is sown mustard mixed with buckwheat.

	Kilos.
2. Mustard and buckwheat siderated	34,330
Containing nitrogen	88

Crop

	Kilos.
Wheat, total yield	11,560
Containing grain	88

Second Experiment

	Kilos.
1. Violet clover siderated, plants and roots	28,050
Containing nitrogen	156

After siderating the violet clover, there are given to the soil 200 kilos. violet clover containing 40 kilos. of nitrogen, and mustard is sown mixed with buckwheat.

	Kilos.
2. Mustard and buckwheat siderated	28,790
Containing nitrogen	77

Crop

	Kilos.
Wheat, total crop	11,665
Containing grain	3,300

or 43½ hectolitres.

Sideration followed by a Crop of Haricots

First Experiment

	Kilos.
Violet clover siderated, plants and roots	45,010
Containing nitrogen	188

CROPS

	Hectols.
1st year, Haricots	27
	Kilos.
2nd year, Wheat, total	8,305
Containing grain	2,690
or 37½ hectolitres.	

Second Experiment

1. Violet clover siderated, plants and roots	45,010
Containing nitrogen	172

Mineral manure is given after the sideration of the clover, and haricots are sown.

The formula of the manure is:

INCOMPLETE MANURE, No. 6, WITHOUT NITROGEN

	Per hectare. Kilos.
Superphosphate	400
Potassium chloride (80 per cent.)	200
Gypsum	400
Total	1,000

CROP

	Hectols.
1st year, White haricots, very fine	34
	Kilos.
2nd year, Wheat, total	10,550
Containing grain	3,038
or 41 hectolitres.	

It must be remarked that the first year we produce at once clover and haricots—that is, manure and a crop. Sideration in this case does not involve the loss of a year. If we consider, further, that the crop of haricots and the straw of the wheat cover the expense of cultivation for both years, it results that we have obtained

$\frac{41}{2} = 20\frac{1}{2}$ hectols. of wheat per hectare and per year *gratuitously,* whilst at present the mean production of France is only 15 hectols., which is devoured by the cost of production.

When I consider that for a century we have been the prey of reformers of all schools and from all sources, I find consolation in the thought that in our country an innate force, born of spontaneous work, has produced the most thorough transformation which the cultivation of the land has ever undergone—a change which may be compared to the transformation which the steam-engine has created in manufactures.

Add to this agricultural transformation that which Leplay and his school demand with such persistence—testamental liberty to raise the authority of the father of the family, the prohibition of the subdivision of an estate below 10 hectares to protect the family home, and you will have realised the cardinal conditions which will make of France a rich and powerful democracy; and you will see our slackened population, arrested in its normal development, resume its confident growth, as in Canada, where the French race in this respect surpasses the English race, which is so much superior to us in old Europe.

The use of Dung produced on the Estate is ruinous

I said in the course of the third lecture that a husbandry which uses as manure merely the dung produced on the farm is fatally ruinous. The Bechelbronn balance-sheet is an infallible proof of this assertion. I reproduce it here, not in a summary condition, but with the details which belong to its three great divisions.

Balance-sheet of the Bechelbronn Farm when it was directed Precarious; Profit,

Dr.

Crops on 50 hectares	Francs
Rent, 90 frs. per hectare	4,500.00
Cost of cultivation	5,340.46
Dung	3,702.60
Profit	2,700.00
	16,243.07

Consumption		Francs	Live Francs
1,837 quintals hay and aftergrowth	@ 3.60 frs.	6,613.20	
561·2 „ clover-hay	@ 3.15 „	1,767.78	
325 hectols. oats	@ 4.54 „	1,475.50	
293·6 quintals potatoes	@ 2.14 „	628.30	
654·2 „ beets	@ 1.22 „	798.12	
422 „ straw	@ 1.25 „	527.50	
			11,810.40
4½ hectols. peas	@ 20.00 „		90.00
Interest at 6 % on capital in cattle and pigs (8,115 fr.)		486.90	
Interest at 13½ % on capital in horses (5,500 fr.)		433.15	
Wages of cowman		417.40	
„ milkmaid		392.00	
„ swineherd		448.00	
„ three ploughboys @ 456.4 frs.		1,369.20	
Interest for six months on wages		73.85	
Paid to blacksmith		401.15	
„ wheelwright		169.10	
„ cooper		11.40	
„ harness-maker		212.80	
Trussing hay and straw		233.65	
Interest for six months @ 5 % on above expenses		25.70	
Fees of veterinary surgeon and medicines		109.30	
Castrating 33 pigs and 5 bulls		15.60	
Various requisites, oils, salt, leather, &c.		542.10	
Value of carts, ploughs, harness, machines, tools, valued as per inventory at 7,300 frs. interest at 10 %		730.00	
			6,071.30
			17,971.70

by Boussingault. Nothing but Farmyard Manure Used. Yield 3,333 Francs Yearly

	Quintals	Francs	Cr. Francs
Produce sold			
56,270 kil. potatoes @ 4.50 frs.		2,532.15	
13,620 „ beets @ 1.60 „		217.92	
1,960 „ clover @ 5.50 „		107.80	
371·6 hectols. wheat @ 19.50 „		7,246.20	
22,680 kil. wheat-straw @ 2.50 „		567.00	
18,740 „ oat-straw @ 2.00 „		374.80	
			11,045.87
Produce consumed			
29,360 kil. potatoes @ 2.14 frs.		628.30	
65,420 „ beets @ 1.22 „		798.12	
56,120 „ clover @ 3.15 „		1,767.78	
42,200 „ wheat-straw @ 1.25 „		527.50	
325 hectols. oats @ 4.54 „		1,475.50	
			5,197.20
			16,243.07
Stock			
Live weight acquired by cattle @ 42½ frs. per 100 kilos.	135	5,737.50	
Milk not consumed by calves @ 12 frs. per. quintal (97 litres)	282	3,384.00	
Weight gained by pigs @ 60 frs. per 100 kilos.	21	1,260.00	
1,290 days' work of horses disposable @ 2 frs. per day	—	2,580.00	
			12,961·50
Days' work of 1,501 horses and 345 cows			1,307.59
710 *tons of dung* @ 5.20 *frs. to balance* . . .			3,702.61
			17,971.70

BALANCE-SHEET OF THE BECHELBRONN FARM—*continued*

MEADOW-LAND

	Francs		Francs
Rent of land	5,410.00	1,837 quintals hay consumed @ 3·6 fr.	6,613.20
Expense of cultivation	2,415.45	335½ quintals hay sold @ 5·5 fr.	1,845.25
Profit	633.00		
	8,458.45		8,458.45

SUMMARY

	Francs
Profit on crops	2,700.00
„ live-stock	00.00
„ meadows	633.00
Total	3,333.00

CHEMICAL MANURES AS COMPARED WITH DUNG

Dung, 100·00:—

Water	80·00	80 per cent. useless to vegetation.
Carbon	6·80	13·29 which are obtained from the atmosphere and the rain.
Hydrogen	0·82	
Oxygen	5·67	
Silica	4·32	5·07 with which the soil is superabundantly provided and which it is not necessary to supply.
Chlorine	0·04	
Sulphuric acid	0·13	
Oxide of iron	0·34	
Soda		
Magnesia	0·24	
Nitrogen	0·41	1·64 per cent. with which the soil is provided only to a limited extent, and which must be supplied by manure. *This is chemical manure.*
Phosphoric acid	0·18	
Potash	0·49	
Lime	0·56	
	100·00	

Dung owes its good effects to the same elements as do chemical manures. Dung is to chemical manure what Peruvian bark is to quinine.

In fact, it is chemical manure mixed with much moisture and a worthless 'gangue.'

HOW PRACTICAL MANURE IS DERIVED FROM ABSOLUTE MANURE, AND FROM THE COMPOSITION OF VEGETABLE SOIL

		Theoretical manure	Practical manure
Natural elements which communicate fertility to the soil	*Organic*	Ammonium salts Nitrates	*Nitrogenous matter*
	Mineral	Potash	*Potash*
		Soda	
		Lime	*Lime*
		Magnesia	
		Oxide of iron	
		Oxide of manganese	
		Chlorine	
		Sulphuric acid	
		Phosphoric acid	*Phosphoric acid*
		Silica	

Comparative Importance of Triennial Rotation and of Sideral Rotation

I invite those who pretend that sideral rotation is merely a reproduction of the triennial system of rotation to compare and reflect on this table, in which the products of both these systems have been summed up :—

Produce of a Farm, 200 hectares

Triennial System, precarious	Francs	*Intense Sideral System*	Francs
66 hectares of wheat at 14 hectolitres per hectare = 924 hectolitres @ 20 francs	18,480	66 hectares at 35 hectolitres per hectare = 2,310 hectolitres @ 20 francs	46,200
1,850 kilos. of straw per hectare on 66 hectares = 122 tons @ 35 francs	4,270	6,000 kilos. of straw per hectare for 66 hectares = 396 tons @ 35 francs	13,860
100 hectares of meadow at 4,000 kilos. of hay = 4,000 tons @ 40 francs	16,000	100 hectares of meadow at 10,000 kilos. of hay per hectare = 1,000 tons at 40 francs	40,000
	38,750		100,060
		The hay being transformed by the cattle.	
		Cereals and straw	60,060
		Meat @ 0.90 francs during 730 days	65,700
		Total	125,760

Comparative Produce of Crops and of Pasture

The better to demonstrate the value of the conversion of meadow into pasture, I contrast the produce of pasture and of the cultivated lands.

With cultivated lands it is necessary to expend 745 francs per hectare in order to obtain a profit of 105 francs, if so much is obtained; and in the case of pasture, with an outlay of 305 francs per hectare, we obtain 352 francs of profit. In support of this assertion, I reproduce the following results of M. Lecouteux:—

Cultivation

	Francs
Rent	125
Preparation of soil	200
Manure	200
Reaping and threshing	80
Carriage	25
Interest and sinking fund	50
General expenses and taxes	50
Unforeseen	15
Total	745

	Francs
35 hectolitres wheat @ 20 francs	700
3,000 kilos. straw	150
	850
Expense	745
Balance	105

Pasture

	Francs
Rent	125
Manure	80
General expenses	50
Interest and sinking fund	50
Total	305

	Francs
Increase of live weight @ 0·9 francs for 730 days	657
Expenses	305
Balance	352

The dung produced is not taken into account.

What Cattle Produce in Pasturage. Opinion of M. Lecouteux

Farmyard dung at ten or eleven francs per 1,000 kilos. means an ox credited with 0·5 franc worth of dung daily—that is, an ox gives daily

	Franc
In value for the butcher	1.5
In dung	0.5

The above figures enable us to establish the fact that a hectare of pasturage which furnishes 730 rations yearly for the support of two fattening oxen is a hectare which yields 730 kilos. of living flesh yearly, when each beast gains daily one kilo. of live weight; and if the kilo. of live weight is worth 0·9 franc, whilst the 50 kilos. of dung produce at the same time a value of 0·5 franc, we have:—

	Daily Francs	Yearly Francs
Meat	0.90	328.50
Dung	0.50	182.50
Per head	1.40	511.00
Per hectare, for 2 head	2.80	1,022.00

EUGENISM[1]

Influence of the Selection of Seed upon the Crop

This question is destined in a few years to become one of the most important in agricultural practice. But before speaking of practical results we must decide on the character and the scope of the theoretical problem.

You may judge by this quotation from my great lectures at Vincennes that as far back as 1864 the questions of the choice and the improvement of vegetable species had attracted my attention:—

'In all vegetable species there are produced certain deviations from the original type, and it is to such deviations that varieties and races among plants are due. Of little importance from a botanical point of view, the varieties are sometimes of great importance agriculturally.

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[1] We have translated M. Ville's term *La Génésique* by Mr. Galton's word *Eugenism* (from εὖ, well, and γεννάω, to produce), signifying the improvement of any species by artificial as opposed to natural selection.

'Under identical conditions of cultivation one variety produces twice as much as another. The wheat of Scotland, for instance, presents great advantages over the chief part of our native wheats.

'There is, therefore, a cause capable of affecting the produce of crops which we must take into account, since it may exaggerate, or, on the other hand, conceal, the real degree of fertility of the soil.

'This influence is of organic origin, since it depends on the very organisation of the plant, and may manifest itself in two different degrees: from variety to variety, or at once as varieties and as individuals. For certain species the yield of each grain is very uniform, as is the case with wheat. Between variety and variety the difference may be considerable; from individual to individual it is trifling.

'There are, on the contrary, certain leguminous plants in which the individual differences often reach enormous proportions. It is not rare to find a single seed giving as great a return as five or six other seeds taken collectively.

'The peculiarity of the varieties, the particular superiority of individuals acting together or separately, represent in the conditions regulating plant life one of the effects which I refer to life; wishing thus to define the origin and the essence of their nature.'

I call this cause of variations, Eugenism.

Here is an example of the extent of the manifestations of eugenism, due to the individual selection of seeds belonging to the same variety :—

EXPERIMENTAL RESEARCHES BY M. GEORGES VILLE

Cultivation of Ten Pea-Seeds in Calcined Sand

	Ordinary Crop Grammes	Remarkable Crop Grammes
Straw and roots	9·97	47·64
Seed	0·50	32·10
	10·47	79·74

In one case the crop is *eight times higher* than the other, and yet the quantity and the quality of the manure were alike in the two cases. What difference was there then between the seed of the two crops? The seeds which gave the exceptional crops were larger and denser, and accordingly we might believe that the excess of substance was the cause of the excess of the yield. But it is nothing of the sort; for if we add to the calcined sand which served as soil a quantity of peas in powder equal to the excess of substance of the large seeds, the crop is neither increased nor diminished.

Sometimes—and this case occurs in haricots—the excess of the crop is due to a second growth of the plant, which is produced after a first formation of pods—*i.e.* after blossoming and the first crop of seed.

In wheat the effects of eugenism are manifested in a different manner; very rarely between seed and seed, but always, on the contrary, between variety and variety. One variety, under equal conditions, gives a crop double that of another.

Here are some examples obtained in a soil of calcined sand with five or six different wheats:—

Crop yielded by Twenty Seeds

		Grammes	Grammes
Fenton wheat	Straw	12·15	14·90
	Grain	1·75	
Girnal wheat	Straw	24·70	16·80
	Grain	2·10	
Fenton wheat	Straw	15·30	18·50
	Grain	3·20	
Igel wheat	Straw	5·50	22·75
	Grain	7·25	

Here also are a remarkable series of crops obtained by M. Thiry, director of the farm of Dombasles, where one variety yields double the crop of another.

EXPERIMENTAL RESEARCHES BY M. THIRY

Varieties of Wheat at Dombasles

Varieties	Yield per hectare	
	Metric quintals	Hectolitres
Hunter's white	17·70	22·98
Wheat from Lorraine	22·00	30·13
Lausanne Nonnette	22·90	30·53
Hybrid Galland	23·80	31·73
Hickling	27·30	36·40
Flanders white	27·70	35·97
White Victoria	28·00	35·00
White Hunter	28·70	35·43
Smooth white Poulard	28·80	38·40
Autumn Victoria	29·20	36·50
Hague wheat	29·30	37·56
Golden drop	29·30	37·56
Blood Red	31·20	40·51
Noé wheat	31·90	43·10
Australian	32·20	42·93
Autumn chiddam	35·00	46·57

For some years the attention of agriculturists has been directed to a variety of wheat of Scottish origin, the *square-head*, which has given such advantageous results in Denmark, Holstein, and a part of Germany that it tends to displace all other known varieties.

The subject is so serious that I do not hesitate to publish in full the excellent report which M. E. Schribaux, the Director of the experimental station for seed-corn at the National Agronomic Institute of Paris, has thought it necessary to devote to this new wheat:—

Productive Varieties of Wheat

Among the wheats of English origin justly in request in highly cultivated countries there is a variety which in the north and centre of Europe enjoys so marked a favour that I think it useful to point it out to French farmers who are not aware of its existence, or who have not yet attempted its cultivation—I mean the wheat with a square ear, the 'square-head' of the English. To whom is due the creation of this variety? On this subject there are different versions. In his remarkable work, 'Les Meilleurs Blés,' M. Vilmorin declares that it was obtained from seed by Mr. Patrick Sherriff, of Mungo's Well, Scotland. On the other hand, Rimpau-Schlanstedt reports that in a journey in England in 1879 many farmers mentioned to him the 'square-head' as an English variety which had been long in cultivation, and the origin of which was unknown.

It is beyond doubt, however, that in 1874 Herr Jensen, Director of Copenhagen, having discovered select wheat-seeds of the square-head variety in the possession of a Scotch farmer of Saltcots, Samuel D. Shirrif, purchased an important lot, with which he supplied his Danish customers, under the name 'Shirriff's Square-head.' This name became in Germany, where it soon penetrated, the subject of an excusable error. Everywhere Shirrif was confounded with his celebrated countryman Shirref.

The titles of nobility of the square-head date from its importation into Denmark. In 1879 it was found on enquiry that in the Danish islands and in Jutland it occupied more than half the area sown with wheat; it is the variety preferred in the beet-sugar districts of Germany. I found it ten years ago in Scania, in southern Sweden, last year in the kingdom of Saxony, and, if I am rightly informed, it begins to be cultivated in Switzerland.

A variety which presents such a power of expansion, the geographical area of which increases so visibly in all directions, merits on every reason the honours of experimental cultivation. Herr Wrede, one of the most eminent farmers of the province of Hanover, with whom I had the good fortune to pass nearly a year, wrote to me a few days ago: 'The introduction of the square-head into Germany marks the commencement of a new era in the production of wheat. In a very few years it has almost entirely supplanted all other varieties, native or foreign. For my own part, I should sow it exclusively if, for the sake of a better distribution of labour, I did not think it better to employ varieties ripening at different epochs.'

The square-head is a winter wheat having a semi-late maturity. It produces a straw very rigid, and scanty in amount in proportion to the grain yielded. As the name indicates the ear is square, compact, scarcely tapering at the point. The grain, well-nourished and of medium size, presents a yellow or reddish tint.

Two circumstances explain the favour—without parallel, I believe, in the history of wheat—which attaches to the square-head. In the first place, the resistance of the straw to laying, and to the action of parasitic fungi, especially rust; these qualities are inseparable. Everyone knows the close relation which exists between the appearance of a parasite and the texture of its host. The straw, which is bent under the weight of the ear, is formed of a yielding succulent tissue, which opposes but a slight obstacle to the penetration of the mycelium of the parasite. The square-head, born under the humid sky of Britain, possesses in the utmost degree the faculty of consolidating its mechanical system under the influence of the more variable climate of the Continent. If its great hardiness permits it to be cultivated almost everywhere, the phytotechnical character just mentioned makes it especially suitable for damp cold soils, for rich alluvial lands, for fields strongly manured, for all those which tend to an excessive development of the foliaceous parts to the detriment of the ear.

The quality of the square-head which demands notice is its yield, at once regular and abundant. Crops of 4 to 5 tons per hectare, or about 55 to 66 hectolitres, which were pronounced fabulous in Germany before the introduction of the square-head, are now no longer rare. Herr Jacobsen, of Copenhagen, affirms that in soils which are very fertile or plentifully manured the 'square-head' produces as a mean at least one-fourth more than the other varieties. The explanation of this fact lies in the resistance of the straw to laying.

French farmers generally declare that at present the cultivation of wheat is ruinous. If considerations of higher importance did not stand in the way, I could, with the numerous figures and details collected in Hanover, demonstrate that wheat yields a large share of the profits of the German farmers.

I will not conclude without recalling the obstacles which in Denmark as well as in Germany would have compromised the future of the square-head if it had not possessed an exceptional value. The slowness with which it enters into vegetation in spring, its mode of growth, which might be called parallel on account of the verticality and perfect equality of the shoots, leave the soil sparingly covered during the first stages of its development. The fear was expressed at first that it would not tiller; the winter cold and the spring frosts were dreaded, but the experience of many years has shown that these opinions were ill-founded.

It is not sufficient to select a very productive variety. The doors of the market must be opened for it. Against the square-head the millers formed an actual coalition to hinder its cultivation, reproaching the new-comer with being poor in gluten and of yielding a flour of second-rate quality. Without doubt the square-head, like all its English congeners, contains less nitrogenous matter than the wheats of the Continent. But everyone knows that in the former the quantitative inferiority of the gluten is largely compensated by a greater elasticity and extensibility. The relatively weak consistence of the square-head demands for grinding a more considerable power than do the hard wheats.

Is the paste raised to too high a temperature, modifying the structure and the plastic qualities of the gluten? This hypothesis is admissible. However this may be, farmers have preferred from the outset to preserve a variety of a high yield rather than return to the wheats of the country bought by the millers at a somewhat higher price. Latterly, the confederacy is disarmed, the millers grind up the square-head along with the harder wheats; as for the price, it is sensibly the same as that of the most esteemed varieties.

I would advise our farmers to cultivate the square-head; I do not say immediately on the large scale, though success does not appear doubtful, but by way of trial against the best local varieties. By multiplying experiments and co-ordinating facts which have been carefully observed, we shall quickly find if the square-head deserves to occupy in our cultivations the place of honour which it has acquired in neighbouring countries.

E. SCHRIBAUX.

All known wheats are capable of being ameliorated by selection.[1] The improvement consists in augmenting the resistance to bad weather, and especially to laying. To this end there are two methods of procedure.

A variety being given, when the wheat has reached maturity a woman is sent through the plots, carrying a bag attached to her girdle, like an apron, with the mouth open. She is furnished with a large pair of scissors, with which she cuts ear by ear the finest stems, those which are firmest and straightest.

The ears are put to dry in the shade, and a centimetre is then cut off from each end of the ear, because at the extremities the grains are small and meagre.

The rest is carefully threshed out, and the produce serves as seed-corn for an exceptionally careful cultivation, the yield of which furnishes in turn seed for the entire exploitation.

---

[1] Major Hallett's Pedigree wheat has been known in England for many decades.

It is sufficient to reap and to prepare with the precautions just indicated two or three hectolitres of wheat to have for the next year a supply for 100 hectares.

If we wish to carry still further the amelioration of the race, a second selection must be made among the first crop of the selected wheat; and always continue this selection uninterruptedly, so as to set aside the three hectolitres necessary for the crop.

In these terms I presented this synthesis for the great Exhibition of 1878:—

Eugenism and its Variations

§ 1. Vegetable species are not immutable types, everywhere constant and always identical with themselves.

§ 2. Each species is capable of certain deviations which remove it from the original species. These deviations produce races and varieties.

§ 3. In other words, vegetable species, just like animals, are capable of improvement by selection, cultivation, and crossing.

§ 4. The differences between the mother species and the varieties, often of little importance botanically, have agriculturally an extreme importance.

§ 5. Under similar conditions one variety may produce two or three times as much as another.

§ 6. The variations depend on the organisation itself of the plant—that is, on the variable intensity of the energy of which the vegetable embryo is the original seat, and which subsequently diffuses itself in all the organs of the plant. I call this form the *genesic*.

§ 7. Eugenism is capable of manifestation in two different degrees: from variety to variety, or from individual to individual.

§ 8. It is manifested among cereals from variety to variety.

§ 9. Leguminous plants manifest it at once from variety to variety, and in one and the same variety from individual to individual.

§ 10. It often happens that a single seed produces ten times as much as another.

§ 11. These privileged seeds give rise to an enormous absorption of nitrogen from the air.

§ 12. If we try with less privileged seeds to produce equivalent effects by an increased dose of nitrogenous manure, we always kill the plants.

§ 13. Upon the cultivation of leguminous plants in calcined sand we can found an absolute demonstration of the fixation of atmospheric nitrogen by plants.

§ 14. No objection can be raised in presence of the inequality of crops yielded in the same plot by different plants of the same kind.

EXTRACT FROM THE LECTURE GIVEN IN 1879 AT ROUEN

At the request of the
Central Society of Agriculture of the Seine Inférieure

By M. GEORGES VILLE

In 1879 the Central Society of Agriculture of the Seine Inférieure requested me to give a lecture on the means of combating the American competition then beginning. In reply to the question placed at the beginning of my lecture, the best thing I can do is to recall how I have appreciated the character of this competition, and by what measures I thought its effects might be encountered. At that time I was considered as an alarmist, and no more attention was given to my predictions than to my counsels.

Subsequently facts have, alas! confirmed all my previsions, and justified the measures which I then recommended.

I submit these declarations to the judgment of agriculturists who are placed by the State above the transient interests of the moment. This quotation is the necessary preface of my new proposals. I said, then, in 1879:—

'It is impossible to ignore the fact that the economical situation of the principal States of Europe is at this moment particularly serious. The crisis which we are traversing has this singular character—that it was first purely financial, extended then to industry, and since has involved agriculture itself.

'But if the situation is serious, it must nevertheless be regarded calmly, without overlooking its difficulties, but without exaggerating them; we must accept the conflict, calling to our aid the resources of every kind which science places at our disposal.

'What adds to the gravity of the situation is, in my opinion, the confusion which it has occasioned in the public mind. Read what is published; it is a real conflagration of conflicting opinions, of statistics without end, leading in opposite directions to such a point that the best-endowed mind has great difficulty in finding its way. This is the first result.

'There is a second:

'It is said that we are traversing a crisis. In my opinion this is an error; it is something worse; we are at the outset of a conflict which appears likely to change the economic conditions of the Old World.

'When England, two centuries ago, lost the sturdy families of Puritans who condemned themselves to exile to preserve the free exercise of their creed, and went to found a new society in the United States, Old England did not expect that from this exodus, sprung from intolerance, there would arise the rudest adversary which she ever had to encounter.

'I repeat, what is called the crisis is not a crisis, it is the prelude of a conflict between the Old and the New World.

'This situation must be viewed without shrinking. The adversary whom we are engaging is so formidable that nothing should be left to chance. History tells us that the Americans, like the English, never engage in a conflict without having first secured all the chances in their favour.

'It is, then, a struggle, pacific, but continuous, without truce, waged by work, by national activity in all forms, a conflict far more redoubtable than wars with weapons. The question here is not to lose or gain a battle. What is at stake is public prosperity and progress, the decay or the decline of the entire country.

'Above all things we must here not introduce politics.

'Is it not, in fact, strange that in certain parts of France we dare not pronounce the word liberty applied to the multiplicity of exchanges without incurring the reproach of seeking to hand over the industry of the country to the alien? It is true that for other regions the word Protection is synonymous with Reaction, and that whoever speaks of compensatory duties, even to the most moderate degree, is considered as an enemy of republican institutions.

'A strange exaggeration of party spirit, as if the American Republic would have hesitated to practise protection, and even prohibition, the day when it seemed favourable to its interests!

'In coming among you, gentlemen, I have formed the resolution to avoid above all things systematic and preconceived ideas, and to adhere to facts the reality of which cannot be contested, to teachings consecrated by experience, and never to be the adherent of a party or a clique.

'Societies are vast organisms which have their conditions of existence like individuals; I will endeavour to search out before you these conditions; I will define the acts by which the productive power of a nation is manifested, and seek what is the relation of dependence between industry and agriculture. The ground being thus cleared of all these incidental questions, I hope that we shall arrive at useful conclusions.

'Human activity, gentlemen, is exerted in two different directions: agriculture and industry; agriculture which creates, and industry which transforms the materials supplied by the former.

'Let us pass to the latter portion: the economic situation of the country, and the American competition.

'I do not experience, gentlemen, any embarrassment in entering upon this part of my subject, however painful to me is the picture which I must present to you.

'Agriculture is not a contemplative art to which we give ourselves up to derive ideal satisfaction without any positive benefit.

'He who buys land wishes to obtain interest on his capital; he who devotes himself to the cultivation of the soil seeks for a profit, the legitimate remuneration for his labour and the risks which he has run.

'But whether we speak of the ground-landlord, of the farmer, or of the labourer, the useful result will be affected by the economic régime of the country, and especially by the state of property.

'You see how America has, in these two respects, the advantage over us.

'In 1869 it received, as a yearly mean, 200,000 immigrants from the Old World. But do you know what a man of twenty years has cost the country where he was born?

'At the lowest estimate 8,000 francs per head.

'Therefore, 200,000 immigrants represent a money value of 1,600 millions of francs in the form of the most accomplished instrument of production.

'But this is not all; with the exception of the Irish, who arrive in a state bordering upon destitution, it is estimated that each immigrant brings with him a sum of 500 to 1,000 francs. For 200,000 immigrants this is an increase of wealth of 100 to 200 million francs. Total, 1,800 millions to 2 milliards on the score of emigrants.

'In the United States the land is worth 15 francs per hectare. The meadow-land 20 to 25 francs. The rent of the soil is *nul.*

'There is no army; no military marine. All the youth is concentrated upon productive work.

'Cultivation is conducted upon immense surfaces where there is free scope for the use of machinery. For conveyance there are water-ways like inland seas, which permit of exportation without transhipment. A population doubling every twenty years. A territory capable of nourishing 500,000,000 men, submitted to a relentless prohibitive system, receiving from us nothing free from duties, and inundating us with a portion of her surplus, which suffices to disturb all the economy of our internal production.

'Let us now speak of France. Land is worth here, as a mean, 2,000 francs per hectare. It is let for 50 to 100 francs.

'As for the constitution of property, reflect on these figures:

'Cultivated area, 46,000,000 hectares, divided into 143,000,000 plots, represented by 14,000,000 distinct properties. This gives one-third of a hectare for the area of each lot if we take the large properties into consideration, and only one-eighth of a hectare if they are excluded.

'Add to complete the picture this other statistical declaration. Of the 14,000,000 properties there are:

'Two millions at 10 to 20 francs
'Two millions at 5 to 10 „
'Seven millions below 5 „

'which leaves 3,000,000 proprietors exempt from personal taxation on account of poverty.

'What system of cultivation can a man follow to obtain value from eight to ten plots of $\frac{1}{6}$ to $\frac{1}{10}$ hectare? Strictly none. The time which he loses in going from one plot to another triples the general expenses. Their smallness excludes, not merely the use of machinery, but even animal power, which is fifteen times cheaper than human labour. When the land has arrived at such a state of fragmentation no production of manure is possible; the land is manured badly or not at all. The continuance of this system strikes a blow at the natural fertility of the land, and by an inevitable reaction public prosperity itself is attacked. This is so true that the mean yield for wheat is scarcely 12 to 14 hectolitres per hectare, whilst it is in our power to raise it to 28 or 30 hectolitres.

'Add to these disadvantages the military law; the heavy taxation; the absence for the farmer of all freedom of action, considering that Article 2102 neutralises the value of the live stock for the benefit of the landowner; the most defective registration in Europe; the taxes on transfer which absorb the rent for three years, and, finally, the absence of credit for cultivation.

'Is it, indeed, credible that agriculture, the yearly produce of which is from seven to eight milliards, has not an institution of credit suited to its wants?

'What, therefore, is our internal situation? We have had, since 1826, deficient yields of wheat, meat, and wool, which become aggravated from year to year.

'As a sadder evidence, our population requires 190 years to double itself, whilst it is doubled on the mean in 50 years in the other countries of Europe. In France there are 48 departments in which population decreases in place of increasing.

'What are we to do and to conclude? Arm ourselves for the struggle, because the struggle is the essence of life which in the present case we cannot escape. Science has done its part, it is for politics to do its share.

'The means of raising our production are not mysterious; but to apply them we need a totality of reforms and creations which cannot be improvised, and whilst we are preparing for them a temporary duty upon wheat of two to three francs per 100 kilos. seems to me very difficult to avoid.

'We must certainly prevent alimentary crises and the artificial rise of the price of subsistence; but can we persuade ourselves that so small a tax, the amount of which scarcely reaches five centimes on a loaf of two kilos., can ever take the character and the proportion of a public calamity now it is asserted that the liberty of the baking business, by flattering certain purely luxurious demands on the part of the consumer, has raised the difference between the price of the sack of flour and the price of bread from eight francs to twenty francs, which corresponds to an increase of ten centimes on the loaf of two kilos.?

'What must we think of the panic which it is sought to create when we know that a moderate duty would have the immediate result of preserving our home market, and with it the security of the rural class? I repeat, the immediate struggle I do not think possible, and I pray that we may not weaken our last national force that remains intact; for if it must be otherwise I do not see how the repair of so great an evil will be possible in the conditions which we are traversing.

'Gentlemen, I propose to open a subscription for diffusing in the rural districts, by means of the experimental fields annexed to our schools, the new notions which I have expounded to you.

'It is not sufficient that great efforts should be made for the immediate application of the procedures to be deduced; it is further needful that our children, rendered familiar with these data of science, should draw from them results which cannot be expected from the present generation.

'To this first foundation we add, by an extension of the idea of association, the creation of local syndicates, destined to procure for our country districts, as cheaply as possible, and free from all adulteration, the fertilising agents which they so pressingly need.

'Let us, then, take the more difficult but not less imperious resolution of tracing out to our representatives in our assemblies the programme of the reforms and the establishments, without which no progress is realisable and every struggle is impossible for agriculture without the gravest perils, not alone for it but for the entire country.

'Then, and only then, there will be a question of competing with the United States.

'America is protected, we are not; America is armed, we are not. Let us protect ourselves so as to have time to arm ourselves; and, to sum up all in a word, let us say: No alimentary crisis, but no sudden attack on the first of our industries!'

Five years have elapsed since this lecture, and it has become evident that America can produce wheat at eight or ten francs, while the cost of production in India descends to three or four francs; and that America and India together dispose of an annual surplus of 40,000,000 hectolitres.

Against such a competition a tax of three francs no longer suffices; it must be immediately raised to eight francs, and we must not hesitate to impose a duty of eighty francs per head on horned cattle.

The economists of pure theory, in reply to our cries of distress, exclaim: 'You lose by your wheat? Very well, raise meat.' This is easily said. But do you know that to change a rotation and to pass from the production of wheat to that of meat there are required three entire years, if not four? for the pasture must be created and a starting-point taken on raising cattle. And during this time what is to become of the farmer? Is he to wait four years for the cereals upon which he is ruining himself, so that he may secure his working expenses?

'No, in such a situation there is only one means of resistance; it is necessary that the alien products, cattle and cereals, must at their entrance upon our soil be met with compensatory duties equal to the charges which our national agriculture supports; and what I say for meat and grain I extend alike to all products. To deny the necessity of this act of restitution and of justice is to deny the evidence, and seek to precipitate the distress of the country to the limit which makes revolutions.

A truce to hollow discussions, and let us get to work! The work which necessity commands is the vote of a duty of eight francs per hectolitre upon wheat, and of eighty francs per head upon horned cattle.

Our farms, deserted by thousands, tell us in effect that the measure cannot be postponed.

Consider the want of animation which reigns in our markets. At twenty francs per metric quintal, which is at present the quotation for wheat, the producer loses six francs per hectolitre.

This year the harvest has been excellent in America; but what will America do with its surplus? Wheat does not keep like an ingot of gold or a pig of copper. It alters in the course of the first year, and the change which its quality undergoes destroys its value. There are only two solutions; it must be sold or distilled. For distillation America is not at this moment prepared. Realisation is therefore compelled, and Europe must sustain severe shocks.

Ah! if in 1866, at the time of the great inquiry into the sufferings of agriculture, we had resolutely taken the measures which opinion demands:—

The abrogation of Article 2102, to restore to the farmer the free use of his capital;

A severe law against fraud in manure;

A precedence over the rights of the proprietor in favour of purchases of manure on credit, and of all real ameliorations;

The reform of the register;

Guarantees of interest to powerful companies capable of effecting with brief delay ameliorations of incontestible result—such as drainage, irrigation, roads, ditches, enclosures, construction of farm-buildings, &c.—the expense being met in thirty years by annual instalments less than the increase of produce attained;

The establishment of narrow-gauge railways, costing scarcely 80,000 francs per kilometre, in place of 800,000 francs as at present;

The reduction of the tax on transfer, which, on the present footing, absorbs three years' rent;

The creation of a vast set of experimental fields attached to the primary schools;

And, as the crown of the structure, local banks to serve as the basis of a powerful system of credit, and especially efficacious legislative arrangements, to arrest the fragmentation of the land, and to promote the agglomeration of the dispersed plots.

If all these measures had been taken according to a plan systematically followed without hesitation, it is probable that, instead of the compensatory taxes which are now demanded, we should have had to fall back upon private initiation to support alien competition. But, as for the moment nothing, absolutely nothing, has been done, we cannot escape from temporary measures of preservation.

Let us return to questions which belong more especially to my domain. Suppose, as a simple hypothesis, that of the 8,000,000 hectares—the area at present devoted to the culture of cereals—we had spread for ten years over the half of this surface—that is, over 4,000,000 hectares—150 francs worth of chemical manures per hectare yearly; the immediate result would have been that, instead of reaping fourteen hectolitres of grain per hectare, which is the actual mean, we should have reaped thirty hectolitres, giving a surplus of 64,000,000 hectolitres, leaving behind them abundance, secure and cheap living, and feeding an exportation which would have rendered England dependent upon us.

And for this what has been wanted? Give the earth a yearly advance of 600,000,000, which the exportation of the excess of our produce would have reimbursed the following year.

Extend the same hypothesis to pasturage, so that, thanks to a supply of chemical manures, in place of 4,000 kilos. of hay per hectare, 4,000,000 hectares would have yielded for ten years the equivalent of

10,000 kilos. of hay. For ten years our animal production would have exceeded our needs by more than 80 per cent., and here, as in the case of cereals, the produce of exportation would have reimbursed our outlay.

Against such a situation America would have found herself impotent, and in default of finding an outlet in Europe for her agricultural produce, the emigrants who live on them would have taken another direction.

For the present these measures have not been taken, and we must seek to moderate the effects of alien competition, and accomplish with brief delay the evolution which is imposed upon us.

Free-trade and protection have nothing absolute: if good to-day, the same formula may become detestable to-morrow.

In fifty years America, better equipped with machinery than Europe, thanks to the exorbitant duties which she has imposed upon our manufactures, may find it more advantageous to suppress these duties than to maintain them. Then England, whose coal-mines will commence to be exhausted, relaxing her industrial activity, will have need of protection. If, thanks to steam and its mineral wealth, England has become a workshop, the production of which is not less than the manual labour of 300,000,000 to 400,000,000 men, the day is, perhaps, not far distant when she will learn to her cost how frail is such a constitution, and to what dangers nations expose themselves who do not produce sufficient for their support. It is the duty of the people, in face of the surprises of universal competition, to secure above all things their liberty of action in commercial matters, to place themselves in safety against every attack, and to manage their resources so as to suffice, and, under all circumstances, to remain masters at home.

This is my last word on the agricultural crisis.

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